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VARIATION IN THE SHREW GENUS *MYOSOREX* IN SOUTHERN AFRICA

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Myosorex Gray is one of the three genera of shrews occurring in Southern Africa, the other two being *Crocidura* Wagler and *Suncus* Hemprich and Ehrenberg. The affinities of these and other African shrews have been discussed in previous papers (Meester, 1953, 1954) and a recent paper by De Balsac and Lamotte (1956) includes an extensive discussion on the intrageneric classification of *Myosorex*, with the description of several new forms from Central and East Africa.

A taxonomic study of *Myosorex* has brought to light certain interesting facts concerning the nature and extent of variation in the Southern African representatives of this genus. These facts, and some speculations based on them regarding the origin and development of the species concerned form the subject matter of the present paper.

MATERIAL STUDIED

The material studied consists of skins and skulls of *Myosorex* from a number of Southern African localities. A list of these localities, with their geographic loci indicated after the system used by Davis (1949), and with the number of specimens from each locality, appears in Table 1. The localities are further indicated by squares on the distribution maps of the two species (Fig. 1).

OBSERVATIONS

Several species and subspecies of *Myosorex* have been described from Southern Africa. Of these only two, *M. varius* (Smuts) and *M. cafer* (Sundevall), are currently regarded as good species (De Balsac and Lamotte, 1956). The other forms are for the most part based on minor variations in color and size, and can consequently all be disregarded, with the exception of *M. sclateri sclateri* Thomas and Schwann, from Ngoye Hills, Zululand, and *M. s. talpinus* Thomas and Schwann, from Umfolosi Station, Zululand, which should be retained as subspecies of *M. cafer* on the strength of their large size and distinctive color.

Myosorex varius occurs as far north as Mariepskop in the Eastern Transvaal. From here it extends westward to the Transvaal Highveld, where it has been collected on the Witwatersrand at Rietfontein, Johannesburg district, Sterkfontein, near Krugersdorp and Randfontein, and also in the Western Transvaal at Koster. Southward it extends to Zululand and Natal, Basutoland, Western Pondoland, inland to Dordrecht and Tarkastad, and along the coastal districts of the Cape Province to Port Nolloth in Little Namaqualand (see Fig. 1). *M. cafer* occurs from Inyanga, Southern Rhodesia, down the eastern escarpment to the Eastern Transvaal, Zululand and Natal, and down to Western Pondoland and Kaffraria, where it has not been collected south of Kingwilliamstown (see Fig. 1).

Myosorex varius and *M. cafer* do not occur north of the Zambesi, and are separated by over a thousand miles from their geographically closest East and Central African neighbors, *M. blarina zinki* De Balsac and Lamotte, from Mount Kilimanjaro, Kenya, and *M. polli* De Balsac and Lamotte, from Lubondai, Kasai, Belgian Congo.

Both Southern African species prefer a moist, densely vegetated environment (Roberts, 1951). They are frequently restricted to mountainous country, as are most of their East and Central African relatives (De Balsac and Lamotte, 1956),

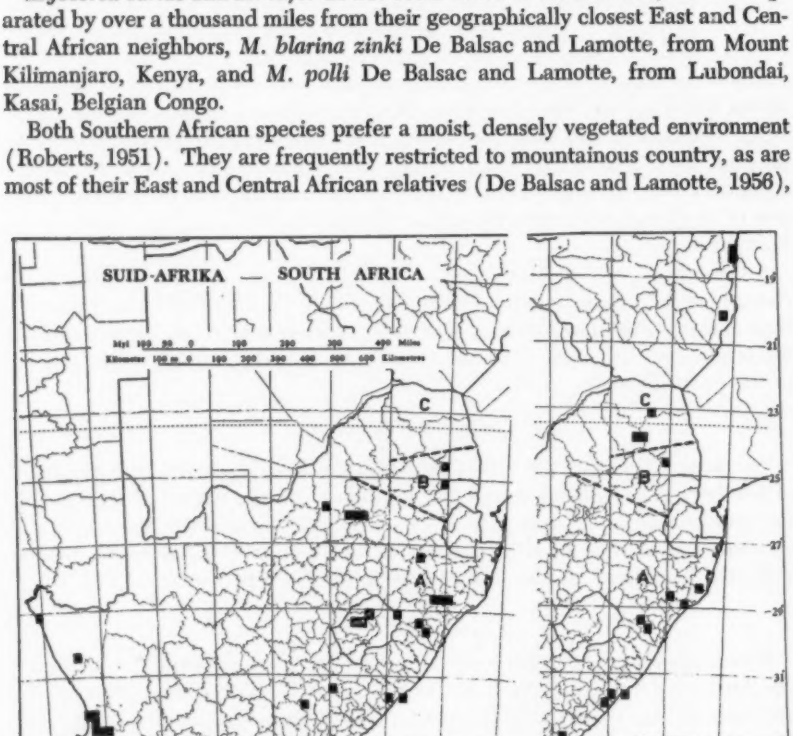

FIG. 1.—Distribution of *Myosorex* in Southern Africa. Left, *M. varius;* right, *M. cafer.* For further details, see text.

and are usually trapped in the dense vegetation lining the banks of mountain streams, or in bush (C. H. B. Grant *in* Thomas and Schwann, 1905*a*, *b*, 1906). These conditions are commonly encountered in some parts of their range, such as the eastern escarpment, the mountains of Zululand and Natal, Basutoland, and parts of the coastal districts of the Cape Province. *M. varius*, however, also occurs in areas where the prevailing conditions are less than optimal, such as the relatively dry, flat Transvaal Highveld and the very dry Northwestern Cape Province.

On the Transvaal Highveld it has been collected at Koster (Roberts, 1924) and Sterkfontein in the dense grass along stream banks, where its requirements of moisture and cover are presumably met.

The coast of the Western Cape Province, where *M. varius* occurs under seemingly very arid conditions, falls within a winter-rainfall area (Wellington, 1955). Furthermore, Wellington points out that while the area north of the Olifants River is marked by low rainfall, decreasing to the north, "the average rainfall, however, fails to record the frequency of mist, especially in the southern part of this belt, where the sandveld surface supports a continuous cover of low succulent bushes only a few inches apart in the extreme south, but with increasing spaces between the bushes as the rainfall diminishes northwards." This succulent zone extends to about the Orange River, but not much further north.

The significance of this is twofold. First, the presence of dense succulent vegetation along the coastal mountains, together with winter rainfall and frequent mist, would create relatively favorable conditions for the survival of *Myosorex* in the south. To the north, where conditions become more arid, and particularly north of the Orange River, where the succulent zone ends, conditions would be less favorable, and might limit the further spread of the genus. This probably explains why *M. varius* does not occur north of Port Nolloth.

The geographic range of *M. cafer* for the most part overlaps that of the more widespread *M. varius*, and material of both species has been collected at several localities, including the Port St. Johns district of Western Pondoland, from which area fairly long series of both species are available. In view of their sympatric occurrence and the number of specimens available (36 of *M. varius*, 63 of *M. cafer*) these two series have been compared in order to find what diagnostic characters exist, and to ascertain the extent of individual variation in these characters.

The following differences between the two species appear from this analysis:

1. *Dorsal color.* *M. varius* is often, although not always, paler than *M. cafer*. Even when this is not the case, however, *M. cafer* has a buffy pelage tinge, which is replaced in *M. varius* by a fawn-colored tinge.

2. *Ventral color.* The belly is pale gray in *M. varius*, with a slight fawn-colored or yellowish tinge. In *M. cafer* the belly is darker, with very little gray, and buffy-brown in color.

TABLE 1.—*Locality list, with loci indicated after the system used by Davis (1949), and the number of specimens from each locality*

LOCALITY	LOCUS	NO. SPECIMENS
Cape Province:		
Port Nolloth	2916 Bb	1
Ezelfontein, nr. Leliefontein	3018 Ac	4
Lamberts Bay	3218 Ab	9
Clanwilliam district	3218 Ba	10
Redelinghuis	3218 Bd	1
Het Kruis	3218 Da	2
Eendekuil	3218 Db	4
Citrusdal	3219 Ca	8
Simonstown	3418 Ab	1
Tokai Retreat	3418 Ab	1
Wolseley	3319 Ac	4
Worcester	3319 Cb	3
La Motte	3319 Cc	1
Robertson	3319 Dd	288
Swartberg Pass	3322 Ac	2
Jonkersberg	3322 Dc	3
Knysna and Deepwalls	3323 Cc	5
Uitenhage	3325 Cd	2
Port Elizabeth	3325 Dc	1
Tarkastad	3126 Cc	6
Grahamstown	3326 Bc	4
Dordrecht	3127 Ac	2
Kingwilliamstown	3227 Cd	6
Ngqeleni	3129 Ca	17
Port St. Johns	3129 Da	81
Sxwaleni Forest	3128 Dd	1
Natal:		
Pietermaritzburg and Hilton Road	2930 Cb	2
Kilgobbin, Dargle	2930 Ac	6
Champagne Castle, Drakensberg	2929 Ab	2
Ngoye Hills	2831 Dc	7
Umfolosi Station	2832 Ac	12
Nkandhla	2831 Ca	9
Mfongosi	2830 Db	1
Qudeni	2830 Da	1
Basutoland:		
Maluti Mtns., etc	approx. 2928	4
Transvaal:		
Wakkerstroom	2730 Ac	6
Rietfontein, Johannesburg	2628 Aa	1
Sterkfontein, Krugersdorp	2627 Bb	1
Randfontein	2627 Ba	2
Koster	2526 Dd	4
Sabie and Spitzkop	2530 Bb	4
Mariepskop	2430 Db	15

TABLE 1, *continued*

LOCALITY	LOCUS	NO. SPECIMENS
Woodbrush and Haenertsburg	2329 Dd	10
Tzaneen	2330 Cc	1
Entabeni, Zoutpansberg	2330 Ab	1
Southern Rhodesia:		
Chipinga	2032 Ba	2
Vumba, Umtali	1832 Bd	6
Inyanga	1832 Bb	25

3. *Tail.* The tail of *M. varius* has a dark stripe, light brown to dark brown in color, on top. This stripe is more or less sharply distinct from the considerably paler color of the lateral and ventral surfaces, which vary from fawn-colored to white. In *M. cafer* the tail is more evenly colored, dark brown to nearly black in color, becoming gradually a little paler below, but with no sharp line of demarcation between dorsal and ventral color.

4. *Feet.* The feet of *M. varius* are light in appearance. The short bristle-hairs of the feet are off-white, yellow, light gray or occasionally fawn-colored. Usually the feet themselves are not darkly pigmented either, although in a few specimens, such as TM 784♀, the feet are quite dark. Even when the feet are dark the short bristles remain light in color.

In *M. cafer,* on the other hand, the feet are darker, and the bristles more richly colored, varying from yellowish-brown to dark brown, nearly black. In both species the lateral surfaces of the hind feet are usually darker than the inner surfaces. Furthermore, the forefeet of both are often somewhat paler than the hind feet. The extent to which fore and hind feet differ in color is never very marked in either species.

5. *Palate.* In the anterior region of the palate of *Myosorex* three fissures occur, one median and two lateral. In *M. varius* the position of the lateral fissures is such that their posterior edges are located posterior to the anterior edge of the median fissure (Fig. 2A). In extreme cases the lateral fissures may be situated fairly far forward, relative to the median fissure, so that their posterior edges are just about in a straight line with the anterior edge of the latter. No case has been found, however, in which their posterior edges are located further forward than is the anterior edge of the median fissure. In *M. cafer,* on the other hand, the lateral fissures are usually situated wholly in front of the median one, so that there is a gap between their posterior edges and the anterior edge of the latter (Fig. 2B). In some cases the posterior edges of the lateral fissures and the anterior edge of the median one may be in line, as in extreme variants of *M. varius,* or they may overlap slightly. In five cases, moveover, the lateral fissures are situated so far back that their posterior edges are well back of the anterior edge of the median fissure, thereby overlapping with average specimens

of *M. varius*. In the bulk of the specimens examined, however, the lateral and median fissures are separated anteroposteriorly by a distinct gap.

It is clear that the relative positions of the palatal fissures do not constitute an absolute character for the separation of the two species. In the first place, when the posterior edges of the lateral fissures are in line with the anterior edge of the median fissure, there is room for confusion as to which species is being dealt with. Secondly, occasional specimens of *M. cafer* may be expected to overlap markedly with *M. varius* and, given sufficient material, the converse may doubtlessly also be expected. In spite of these shortcomings, the position of the palatal fissures was used in this study, as no other skull character was found which allows even the degree of separation of the two species which this character makes possible.

Several further characters were recently suggested by De Balsac and Lamotte (1956), including differences in size and in dentition. These differences do not appear to be diagnostic. *M. cafer* is clearly larger than *M. varius*, particularly in certain parts of its range. This is the case, for instance, in *M. c. sclateri* and *M. c. talpinus*. However, these size differences are not marked enough to be of use in distinguishing between the two species. Table 2 shows that the Port St. Johns district populations of *M. varius* and *M. cafer* are closely comparable in size, although the latter is slightly larger on the whole.

As regards the reported differences in dentition, no characters were found that are marked and constant enough to allow the separation of the two species. The teeth of *M. varius* tend to be less brachydont than those of *M. cafer*, but such differences in height as do exist on the average are minute, and often masked by individual variation and tooth wear. Consequently, this character does not appear to be of diagnostic importance.

It must be stressed at this point that the Port St. Johns district populations of *M. varius* and *M. cafer* are quite distinct morphologically, and are readily distinguishable on the basis of the color of the dorsal and ventral surfaces, foot

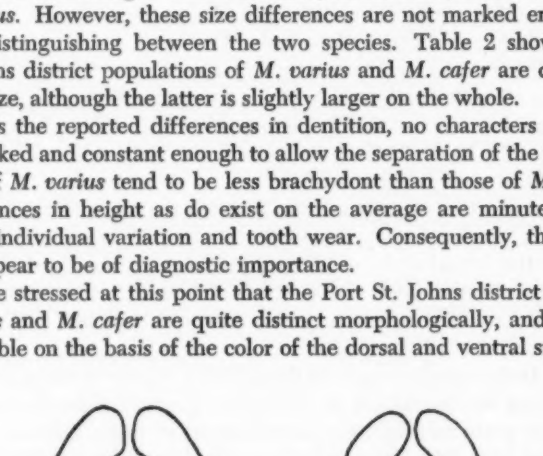

FIG. 2.—Diagrammatic representation of the relative positions of the palatal fissures in (A) *Myosorex varius* and (B) *Myosorex cafer*.

TABLE 2.—*Comparison of certain measurements (in mm.) of M. varius and M. cafer from Port St. Johns district, Western Pondoland*

MEASUREMENT	*M. varius*			*M. cafer*		
	N	Min–Max	*M*	*N*	Min–Max	*M*
Head and body length	46	72–95	85.1	58	74–105	87.4
Tail length	45	31–50	38.9	58	36–50	43.4
Condylo-incisive length	36	20.3–23.6	22.4	40	22.2–24.1	23.2
Maximum braincase width	33	10.0–11.1	10.7	29	10.6–11.8	11.1
Length of upper toothrow	44	8.9–10.7	9.7	49	9.5–10.5	10.0
Bimaxillary width	44	6.4–7.5	7.0	49	6.6–7.4	7.0

color, and the color pattern of the tail. The position of the palatal fissures is less satisfactory as a character, but with the external features here discussed it leaves little doubt that the two populations are specifically distinct.

In discussing geographic variation in the diagnostic features of the two species under discussion, it has proved convenient to subdivide the geographic range of *Myosorex* in Southern Africa into three arbitrary zones. The first, marked *A* on the distribution maps (see Fig. 1) includes the Transvaal Highveld, and the whole of the range of the genus *south* of Mariepskop and the Sabie district, in the Eastern Transvaal. Zone *A* therefore extends over the Transvaal Highveld, the Southeastern Transvaal, Natal and Zululand, Basutoland, and the coastal districts of the Cape Province.

Zone *B* includes only the area from the Sabie district to Mariepskop. Zone *C* includes the localities north of Mariepskop and south of the Zambesi where *Myosorex* occurs, i.e., the northern range of *M. cafer* from Tzaneen, Haenertsburg and Woodbush, along the eastern escarpment to Inyanga.

ZONE A. In this zone, while there is some variation in color and size, the diagnostic characters remain constant on the whole, and the two species are quite distinct.

1. *Dorsal color.* Extreme color variation is found in *M. c. sclateri* from Ngoye Hills and *M. c. talpinus* from Umfolosi Station, which are considerably darker on the whole than other *M. cafer*, and markedly tinged with black. In addition, extreme *M. c. sclateri* and most *M. c. talpinus* are glossy in appearance, and not grizzled as is the case elsewhere in the range of this species. This is the consequence of the extremely dark buffy brown color of the subterminal bands of individual hairs, which do not contrast strongly with the blackish-brown tips, so that the hairs, from the base of the subterminal bands upwards, appear evenly blackish-brown.

Less marked color variation also occurs in other parts of the range of *M. cafer*, as well as in that of *M. varius*. In particular the latter species seems distinctly paler at its western extreme in Little Namaqualand than it is further east. This may be an adaptation to the relatively arid conditions prevailing in the Northwestern Cape Province.

In spite of this color variation, dorsal color remains distinctive throughout

Zone *A*, so that the two species can be distinguished on the basis of the fawn-colored tinge present in *M. varius*, as against the buffy tinge in *M. cafer*. This applies even in *M. c. sclateri* and *M. c. talpinus* which, although dark, retain a buffy tinge.

2. *Ventral color.* The intensity of belly color may vary from place to place, as in *M. c. sclateri* and *M. c. talpinus*, in which the belly is decidedly darker than in *M. cafer* from Port St. Johns, or in the series of *M. varius* from the Western Cape Province, in which it is quite pale, often with yellow or fawn-colored tinge. Specimens of *M. varius* from the Transvaal Highveld have a darker belly than is found elsewhere, with more of a buffy tinge. In spite of this, however, the paler belly of *M. varius* remains quite distinct from the darker, more buffy belly of *M. cafer* throughout Zone *A*.

3. *Tail.* Two specimens of *M. varius* were found in which tail color is intermediate. These are TM 753♂, from Knysna, Cape Province, and TM 9005, immature ♀, from Jonkersberg, Cape Province. In these, although the ventral surface of the tail is quite markedly paler than the dorsal, there is a gradual transition between dorsal and ventral color. Both specimens have discolored patches on their tails, the former a yellowish patch about halfway down the tail, and the latter a dark patch at the base. These aberrations suggest that the tails of these two specimens are abnormal in more than just color pattern, so that the significance of the fact that they are intermediate in this respect is doubtful.

In all other available specimens of both *M. varius* and *M. cafer* from Zone *A*, tail color pattern remains constant.

4. *Feet.* The differences in foot color between the two species, as seen in the material from the Port St. Johns district, remain constant throughout Zone *A*.

5. *Palate.* As could be expected from examination of the series from Port St. Johns, the positions of the palatal fissures are somewhat variable.

Seven of a series of 288 skulls of *M. varius*, recovered from owl pellets collected at Robertson, Cape Province, one *M. varius* (KM 760♂) from Redelinghuis, Cape Province, and one of two *M. varius* (TM 10494♂) from Rietfontein, Johannesburg, have the fissures as in *M. cafer*. In two of seven skulls of *M. c. sclateri* (TM 790♀ and TM 791♀) from Ngoye Hills, Zululand, the fissures are intermediate. Except for these, and the exceptions noted in the Port St. Johns district material, the fissures remain constant in both species throughout Zone *A*.

Zone *B*. In this area there is more of a tendency toward variation in individual characters, but it is still possible to identify specimens without doubt as belonging to either one or the other species.

1. *Dorsal color.* The available material from Zone *B* is easily identifiable on the basis of dorsal color, which remains distinct in both species.

2. *Ventral color.* In eleven specimens of *M. varius* from Mariepskop, and four from Sabie district, belly color is as in material from the Transvaal Highveld, i.e., a little darker and more buffy than further south. It is not so dark, however, as to allow any doubt about these specimens belonging to *M. varius* rather than *M. cafer*, which also occurs at this locality.

3. *Tail.* Three specimens of *M. varius* from Spitzkop, Sabie, have fairly dark tails. In one of these, TM 10306♀, tail color appears to be intermediate in that, although it is paler below than above, there is no sharp demarcation between dorsal and ventral color. The same is the case in TM 10442♂, *M. varius*, from Mariepskop. In the rest of the material from Zone *B*, tail color is distinct.

4. *Feet.* In TM 10442, from Mariepskop (see above) some dark hairs, similar to those found in *M. cafer*, occur on the feet. However, paler hairs are also present, and the color of the skin itself is pale, so that in appearance the feet are only slightly darker than is usual in *M. varius*. In TM 10304, from Spitzkop (see above) the hind feet are darkly pigmented, but the hairs on the feet are light, so that hind foot color is intermediate. In this specimen, furthermore, the forefeet are decidedly paler than the hind feet, and agree in color with other *M. varius*. In the other two specimens from Spitzkop (TM 10305♂ and TM 10306♀) the forefeet are also markedly paler than the hind feet, although both fore and hind feet fall within the range of variation of *M. varius*. In TM 7810♂, *M. varius*, from Sabie the forefeet are only very slightly paler than the hind feet. This is also the case in the material of both *M. varius* and *M. cafer* from Mariepskop.

5. *Palate.* One of four *M. cafer* (TM 10436, ?) and one of eleven *M. varius* (TM 10444♂) from Mariepskop are atypical in respect of the palatal fissures. In the other specimens from Zone *B* this character remains constant.

Zone *C*. In this zone, in which only *M. cafer* is represented, the diagnostic features are very variable. This variability becomes particularly marked to the north, where there is continuous intergradation between the extremes represented by the features of the two species. Some specimens of *M. cafer* from Inyanga are indistinguishable from *M. varius*.

1. *Dorsal color.* Eleven specimens of *M. cafer* from the Tzaneen district in the Northeastern Transvaal vary in respect of dorsal color from that of this species to that of *M. varius*. In a single *M. cafer* from Zoutpansberg (TM 6800♂) color is typical. Of two specimens from Chipinga, Southern Rhodesia, one (A 3·7/5·11) has dorsal color as in *M. cafer*, while the other (A 3·7/5·10) is intermediate. In five specimens from Vumba, Umtali, and 25 from Inyanga, color varies from that of *M. cafer* to that found in *M. varius*.

2. *Ventral color.* In the material from the Tzaneen district belly color varies from that of *M. cafer* to a condition similar to that found in specimens of *M. varius* from the Transvaal Highveld and Zone *B*. The Zoutpansberg specimen is again typical. Both specimens from Chipinga are intermediate, and the material from Vumba, Umtali and from Inyanga varies in the same manner as that from the Tzaneen district.

Variation in ventral color appears to be related to that in dorsal color, so that paler specimens usually have paler, less buffy bellies, while in darker animals belly color is correspondingly darker and more buffy. This, however, is not invariably the case—A 3·7/5·5♂, from Woodbush, has belly color similar

to that of *M. varius*, while dorsal color is as in *M. cafer*, to which species it belongs.

3. *Tail.* In TM 10434♂ and KM 6051, ? from Haenertsburg tail color is as in *M. varius*, although body color identifies them as *M. cafer*. TM 794♂ from Tzaneen is intermediate, close to *M. varius*, although body color is as in *M. cafer*. Both Chipinga specimens are also intermediate, but closer to *M. cafer*. In the specimen from Zoutpansberg and the Vumba material, all *M. cafer*, tail color is typical. The Inyanga material varies from the pattern found in *M. varius* to that of *M. cafer*.

Variation in tail color in Zone *C* appears to be independent of that in the other characters here discussed.

4. *Feet.* In KM 6051, ? from Haenertsburg (see above) the color of the hind feet is intermediate. In the rest of the material from the Tzaneen district, and in the Zoutpansberg, Chipinga and Vumba, Umtali specimens, the hind feet are consistently dark, as in *M. cafer*. In the Inyanga material, on the other hand, hind foot color varies from that of *M. varius* to that of *M. cafer*, although more frequently resembling the latter species. Variation in hind foot color is, moreover, independent of variation in the other characters here discussed.

The color differences between fore and hind feet discussed above become very marked in the material from Zone *C*. In the Chipinga specimens forefeet are as in *M. varius*, although hind feet are as in *M. cafer*. In the Vumba, Umtali material forefeet are consistently somewhat paler than hind feet, although not as markedly as in the Chipinga material. In a number of specimens from Inyanga, as in the Chipinga specimens, color of the forefeet is as in *M. varius*, while that of the hind feet is as in *M. cafer*. In others, although the difference is not so marked, forefeet are noticeably paler than the hind feet. In still others, such as TM 10488♀, color of fore and hind feet is identical.

5. *Palate.* In the material from the Tzaneen district, four of eleven specimens resemble *M. varius* in respect of the position of the palatal fissures, while a fifth is intermediate. Similarly, the Zoutpansberg specimen and three of four skulls seen from Vumba, Umtali, have the fissures as in *M. varius*. The Inyanga material includes five specimens with palates of the *M. cafer* type, and seventeen with the *M. varius* type. Two are intermediate. Variation in the position of the fissures is again independent of that of the other characters here discussed.

DISCUSSION AND CONCLUSIONS

To sum up, then, the following facts appear from the present study: Populations of *M. varius* and *M. cafer* occurring in Zone *A* are readily distinguishable on the basis of color of the dorsal and ventral surfaces, color pattern of the tail and foot color. There is virtually no overlapping in these diagnostic characters. There is some overlap in the relative positions of the palatal fissures in the two species, but this character too remains constant in the majority of cases. The fore feet may be slightly paler than the hind feet in both species.

In Zone *B* there is some variation in individual characters, although by considering all the characters together it is still possible to identify specimens as belonging to either one or the other species. In this zone, too, the tendency for the forefeet to be paler than the hind feet becomes quite marked.

In Zone *C* the diagnostic characters of *M. varius* and *M. cafer* vary freely and, for the most part, independently. Individual specimens show every stage of intergradation between the features of true *M. varius* and *M. cafer*, although on the whole resemblance is much more with the latter species.

In order to explain how this situation may have arisen, it is necessary to state the following:

1. The Inyanga area is the most northern extreme of the range of *Myosorex* in Southern Africa, and is separated to the north by over a thousand miles from the nearest East and Central African localities inhabited by this genus.

2. Ecologically, *Myosorex* appears to prefer moist regions, with dense vegetation, and the genus is often restricted to mountain slopes, although this is not invariably the case—for instance, *M. varius* occurs in the Transvaal Highveld, in flat country.

3. Immediately south of the Cunene-Zambesi border, which separates Southern Africa from East and Central Africa, optimal conditions for the spread and survival of *Myosorex* exist only along the eastern escarpment of Southern Rhodesia.

4. The Inyanga area, being on the eastern escarpment and representing the most northern extreme of the distribution of *Myosorex* in the south, is the most likely focus of the spread of the genus throughout this area. Further, because in this area optimal conditions are restricted to the eastern escarpment, southward spread from Inyanga probably proceeded along the escarpment.

5. Geological evidence indicates that the Pleistocene epoch of Southern Africa was marked by a number of alternate wet and dry periods, termed respectively pluvials and interpluvials. Several well-marked episodes are at present recognised, termed the First, Second, Third and Last Pluvials (Oakley, 1954).

6. During the interpluvials relatively arid conditions, prevailing particularly in southeastern Southern Rhodesia and the Limpopo River basin, would have formed a barrier to the southward spread of *Myosorex*. In this area there is a break in the escarpment, and the terrain is relatively flat. During the present interpluvial, which for want of more accurate information may be regarded as representative of other dry periods, the mean annual rainfall is fairly low (10–20 inches) and the predominant vegetation type is Mopani bush (Wellington, 1955). These factors would effectively prevent the spread of the genus. During a pluvial, with a 10-inch increase in mean annual rainfall, and presumably corresponding changes also in vegetation type, it is conceivable that *Myosorex* could spread through this area, in spite of the flat nature of the terrain, as it has done on the Transvaal Highveld.

It is possible, if the above points are accepted, to explain the present situation in *Myosorex* by assuming a double invasion of South Africa by this genus. The first wave of colonization, which led to the establishment of *M. varius*, moved south along the eastern escarpment to the Eastern Transvaal, where it sent off a branch to the Transvaal Highveld, through Zululand, Natal and Basutoland, to the coastal mountains of Western Pondoland, inland to the Dordrecht and Tarkastad areas, and along the coastal districts of the Cape Province to Little Namaqualand. The spread was probably made possible by favorable environmental conditions such as would exist during a pluvial. The fossil *M. robinsoni* from the Lower Pleistocene deposits of Sterkfontein, near Krugersdorp and of Makapansgat, near Potgietersrust, dates from the First Interpluvial (C. K. Brain, *in litt.*). This indicates that at this stage *Myosorex* was already present in the Transvaal Highveld. Consequently the spread must have occurred before or, probably, during the First Pluvial. If the latter was the case, the relatively moist conditions prevailing during the First Pluvial would have facilitated the spread of the first wave, not only into the Highveld, but also across the gap in the eastern escarpment in the Limpopo River basin and southeastern Southern Rhodesia, and into the Northwestern Cape Province. After establishment, survival in less than optimal areas would be ensured if islands of favorable habitat in these areas could be colonized. This has probably happened where *M. varius* occurs in the Transvaal Highveld (see above) and may also be true about its occurrence in other less than optimal areas.

Later, perhaps during the First Interpluvial, the first wave was isolated from the parent stock by a barrier of unfavorable conditions which arose somewhere between the Mariepskop area of the Eastern Transvaal and the Inyanga area of Southern Rhodesia. As previously stated, such a barrier may have arisen in the Limpopo River basin and southeastern Southern Rhodesia during dry periods.

During the period of isolation the survivors of the first wave underwent genetic change, until eventually they were reproductively isolated from the parent stock, and had evolved into a different species, either *M. varius* or a form ancestral to it.

Subsequently, presumably during the Second or Third Pluvial, a second spread of *Myosorex* took place, following the same route as the previous invasion, because of similar habitat requirements. This wave represents *M. cafer* or an ancestral form of this species. Where the second wave met the survivors of the first, presumably in Zone *B*, the two stocks were reproductively isolated and acted as good species with similar habitat requirements, and therefore competed with each other ecologically.

Two alternatives exist when two species compete ecologically: either the one will go under in the struggle for existence, or be driven away, or the two species will diverge ecologically, so that it becomes possible to coexist without competing too strongly for requirements of food and shelter. The sympatric

occurrence of *M. varius* and *M. cafer* in a number of localities indicates that ecological divergence must have taken place.

This divergence was probably genetically based and could be expected also to manifest itself in morphological divergence. Such morphological differentiation would account for the differences existing between present-day representatives of *M. varius* and *M. cafer*. Brown and Wilson (1956) have described a similar process, which they call "character displacement," and have given numerous examples. The present case differs from the phenomenon as described by them, notably in the fact that where *M. varius* alone occurs, its morphological features do not overlap with those of *M. cafer*. Instead it remains quite constant and is, if anything, more easily recognizable than where it coexists with *M. cafer*.

In both species morphological differentiation has involved a reduction in variability, as compared with the parent stock. When the second wave met the survivors of the first wave the morphological features of the former presumably represented the full range of variability of the parent stock, as seen in the material from the Inyanga area, and therefore overlapped with those of the latter, which may or may not at this stage have already evolved to the point of resembling present-day *M. varius*. No new morphological characters evolved where the two species met, and in each one extreme of parental variability became established; in *M. varius* the extreme characterised by pale feet, bicolored tail, and more fawn-colored dorsal and ventral surfaces, and in *M. cafer* the other, marked by dark feet, unicolored tail, and more buffy dorsal and ventral color.

Because of the presence of reproductive barriers and the development of ecological divergence, it was possible for *M. varius* and *M. cafer* to exist side by side. There was therefore no obstacle to the further spread of the latter species to favorable localities further south, even though these were previously occupied by *M. varius*. The dark-footed species was therefore able to extend its range to its present southern extreme in the Kingwilliamstown area.

Finally, regarding the names to be applied to the species involved in the phenomenon here discussed, according to the argument set out above the animals involved in the first wave of colonization are genetically and perhaps physiologically, although not morphologically, distinct from the parent stock, and should be recognized as belonging to a different species, viz. *M. varius*. There is no need to assume, however, that the second wave diverged sufficiently to warrant recognition as a separate species, so that the same name, *M. cafer*, can be applied to the parent stock as to the animals involved in the second invasion.

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SUMMARY

1. Two species of *Myosorex* occur in Southern Africa. The first, *M. varius* (Smuts), is found in the Transvaal Highveld, the Eastern Transvaal, Zululand and Natal, Basutoland, Western Pondoland, Dordrecht and Tarkastad, and along the coastal districts of the Cape Province to Port Nolloth in Little Namaqualand. The second, *M. cafer* (Sundevall), occurs from Inyanga, Southern Rhodesia, down the eastern escarpment to the Eastern Transvaal, Zululand, Natal, Western Pondoland and Kaffraria, where its most southern record is from Kingwilliamstown. The subspecies *M. cafer sclateri* (Thomas and Schwann) from Ngoye Hills, Zululand, and *M. c. talpinus* (Thomas and Schwann) from Umfolosi Station, Zululand, are regarded as valid.

2. Both species prefer a moist, densely vegetated and often mountainous habitat, although *M. varius* particularly is not restricted to it.

3. In the south the two species are quite distinct, and can be easily recognized on the basis of dorsal and ventral color, foot color, the color pattern of the tail and, to a lesser extent, on the position of the palatal fissures.

4. In the Northeastern Transvaal and Southern Rhodesia, however, populations occur that are very variable in respect of these characters. At Inyanga, Southern Rhodesia, a population occurs which shows complete intergradation between the extremes of variability represented by the two species.

5. An explanation of this phenomenon is attempted on the assumption that the two species represent two different waves of colonization, both starting in the Inyanga area, and spreading by the same route into the rest of Southern Africa. The first, which led to the establishment of *M. varius*, was cut off from the parent stock by unfavorable conditions, perhaps during a dry interpluvial. The barrier may have arisen in the Limpopo River basin and southeastern Southern Rhodesia. During isolation the first wave became reproductively isolated from the parent stock, so that when a subsequent wave—leading to the establishment of *M. cafer*—moved down and met the first, they acted as different species. As a consequence of ecological divergence which allowed coexistence without competition, the two species diverged morphologically, so that in each an extreme of parental variability became established.

6. The first wave has become genetically distinct from the parent stock and hence should be regarded as a different species. There is no need to assume, however, that the second wave is specifically distinct from the parent stock. There is, therefore, no need to distinguish taxonomically between the second wave and the parent stock, and the same name, *M. cafer*, can be applied to both.

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KEEPING BATS IN CAPTIVITY

BY ROBERT T. ORR

During the past ten years the writer, assisted by Mary Louise Perry, Berta B. Kessel and Jacqueline Schonewald, has been keeping bats in captivity for purposes of study. As a result, certain techniques have been developed which may be of use to others who find it necessary to maintain these animals for research.

Several hundred bats representing 12 species were kept for periods varying from months to years. The species involved were: little brown myotis (*Myotis lucifugus*), Yuma myotis (*M. yumanensis*), fringed myotis (*M. thysanodes*), Indiana myotis (*M. sodalis*), California myotis (*M. californicus*), Mexican fish-eating bat (*Pizonyx vivesi*), big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), western lump-nosed bat (*Corynorhinus rafinesquii*), pallid bat (*Antrozous pallidus*) and Mexican free-tail bat (*Tadarida mexicana*). All individuals except those belonging to two species were secured in northern or central California. The Indiana myotis were captured by Wayne H. Davis in West Virginia and the fish-eating bats by Prentice Bloedel near Guaymas, Sonora, Mexico.

Field methods.—Before discussing the care of bats in the laboratory a few suggestions might be in order regarding the capture of these animals in the field for live study. Considerable care should be exerted to avoid injuring bats at such times. Although they are rather hardy creatures, an injured individual has less chance of survival than one that has not been hurt. Most bat collectors make use of long-handled insect nets and long forceps (10–12 inches) for catching bats in daytime roosts. Dexterity in the use of both these tools is a great advantage. The net should not be used as a fly swatter to produce

concussion which may ultimately cause death nor should forceps be used in such a way as to tear flight membranes or cause dislocations.

Another method of collecting bats involves the use of fine wires* strung no more than 1½ inches above small bodies of water to which bats come to drink in the evening. The wires trip the bats as they skim close to the surface and cause them to fall into the water from which they can be removed as they swim to shore. This method was first suggested by Borell (1937) and has since proved very successful. Its use, however, is limited to small ponds and water tanks, particularly in desert areas.

Mist nets are also employed by some bat collectors and are effective, especially when stretched across the entrances to caves and tunnels from which there is only one exit. The use or even possession of these nets, however, is illegal in some states.

Since recent studies have shown that some bats may be carriers of rabies it is wise for any bat collector to wear cotton or light leather gloves as a protection against being bitten. A cotton bag, such as a flour sack, is a handy container in which to place these animals as they are captured. Later they may be transferred to cages.

In winter there are relatively few problems concerned with the transportation of captured bats from the field to the laboratory. In summer, however, particularly in regions where the temperature is high, it is necessary to keep the animals cool. Wet sacks placed over the cages are often sufficient to accomplish this. If ice is available a portable ice box will prove most practical. It requires little ingenuity to construct a small retaining cage that will fit in such a cooling unit. There are numerous inexpensive, portable ice boxes on the market that hold 25 pounds of ice, sufficient to last several days.

Laboratory care.—The writer has previously described (Orr, 1954) the type of cage that he found most satisfactory for housing bats in the laboratory and the manner in which they are best kept so as to cause the least disturbance to the animals.

Papers placed on the bottom of the cages to catch food particles, droppings and urine should be changed daily. Each cage should be washed with detergent weekly and with Clorox every two weeks. Food and water dishes, likewise, should be washed daily.

It has been found practical to remove all of the ectoparasites from wild-taken bats before they are placed in laboratory cages. Ticks, Diptera and other relatively large parasites can be removed with a pair of forceps. Heavy mite infestations on the flight membranes are best eliminated by washing in warm water containing tincture of green soap. Several applications may sometimes be necessary.

Disease.—No contagious diseases were evident among the various kinds of bats kept in captivity, with one exception. On July 28, 1954, a pallid bat that

* Since this paper was submitted for publication, Constantine (Jour. Wildl. Mgmt., 22: 17–22, 1958) has described a new and effective method of collecting bats employing a frame containing fine, vertical wires spaced about one inch apart over a receptacle.

had been captured several months previously in central California was received at the California Academy of Sciences. This bat was one of a number that had been used in a study on the effects of X-irradiation at the U.S. Naval Radiation Laboratory in San Francisco. Since it has been subjected to 500 *r* units of X-radiation on June 7, 1954, the appearance of some lesions on the flight membranes the following August did not at first appear unusual. However, when a non-irradiated bat in the same cage developed similar lesions in October, suspicion was aroused and an examination under a low-powered microscope revealed the presence of sarcoptic mites. Specimens were sent to Dr. Edward W. Baker of the Insect Identification and Parasite Introduction Center, U.S. Department of Agriculture, Washington, D.C., and identified as belonging to the genus *Teinocoptes*. According to Dr. Baker this was the first known record of this sarcoptic mite in the United States. Styles and Nolan (1931) record mites of this genus only from Megachiroptera of the genus *Epomophorus* from Africa.

The bat that had been the original source of the infection died on November 2, 1954, presumably as a result of severe scabies. Six other pallid bats that had been in the same cage had contracted the disease by then. One of these died on May 9, 1955, but the others recovered after about one year of treatment. The treatment consisted of the application of dilute Wydane, a commercial parasiticidal solution containing chlordane, pine oil and kerosene, every ten days to the ears and flight membranes on which the lesions were largely confined. It is rather interesting to note that, although the bats were dormant from November 17, 1954, to March 7, 1955, as a result of being placed in a room maintained at about 40°F., this did not eliminate the parasites, although it temporarily arrested the progress of the infection.

Excess weight.—Bats, like many other animals, tend to overeat once they have become accustomed to taking food in captivity. If more than one individual is kept in a cage it is unsatisfactory to limit the amount of food since the greedier bats may consume more than their share. A few minutes of exercise each day is one solution to this problem. This can be accomplished by permitting them to fly about in a closed room containing a minimum amount of furniture or other objects that might provide hiding places.

Excessive increase in the weight of captive bats is most noticeable in the late fall and early winter months. This is the time when many species in the wild rapidly accumulate surplus fat to tide them over the period of winter dormancy. Members of the genus *Antrozous* and those of the genus *Myotis* that were studied could be induced to become dormant for three or four months with no ill effects by being placed in a refrigerated room where the temperature was maintained at about 40°F. No food was given during such periods but water was essential and the cages were covered with moist cloths to maintain fairly high humidity. At the end of several months of dormancy all traces of excess fat were gone. Mexican free-tailed bats maintained under identical conditions never survived more than six weeks and rarely more than three or four weeks.

Food.—A few bats will take food in captivity without any training. Most, however, have to be hand fed for varying periods of time. Of the various kinds that the author has kept, pallid bats appeared to adjust themselves most rapidly to captivity. Many would take food of their own accord the first night of capture and few had to be hand fed more than two or three days. Most myotis and Mexican free-tailed bats required about one week before they learned to find their food. Big brown and western lump-nosed bats required several weeks and, in the author's experience, hoary and red bats did not learn to feed by themselves in less than a month, sometimes much longer. In hand-feeding a bat the simplest method is to place the animal on a table and cover all but its head with your hand. Cut pieces of meal worms may then be forced into its mouth with a pair for forceps. Usually when the struggling animal has tasted the food it will begin to eat.

As has previously been reported (Orr, 1954) a number of different types of high-protein-content foods were tried on insectivorous bats with varying degrees of success. However, after a year or two most captive individuals showed signs of dietary deficiency in the form of loss of hair or swelling of the joints. On the advice of Mary Louise Perry, who assisted the author in caring for some years, the simplest and yet most satisfactory diet proved to be meal worms (the larvae of the flour beetle, *Tenebrio molitor*) supplemented with a vitamin mix.

At first the meal worms were scalded for a few seconds before being placed in the food dishes in the cages in the late afternoon. This was merely to prevent them from crawling out of the shallow containers and scattering before the bats came to feed. Even in captivity most bats wait until dusk before they partake of food. Later it was found that even small species, such as members of the genus *Myotis,* readily learned to climb into finger bowls from which live meal worms could not escape. Since then only live worms have been used.

Numerous vitamin mixes were tried but only Stuart Formula has proved completely satisfactory. This contains vitamins A, D, E, B_1, B_2, B_6, niacin, niacinamide, panthenol, iron, iodine and manganese. It can be obtained in liquid form and each bat should be given a drop every other day. It is easily administered with a small pipette that can be inserted into the animal's mouth. The addition of this formula to the diet of captive animals kept by the writer has produced some remarkable results. Two pallid bats and a Mexican free-tailed bat that had almost completely lacked hair for over a year assumed normal pelage within a period of a few months. It has also proved a valuable aid in restoring and maintaining health in other types of mammals as well as birds kept in confinement.

The author's first experience in the care of fish-eating bats (*Pizonyx vivesi*) in the laboratory occurred on May 3, 1954. On this date Prentice Bloedel, then a graduate student at the University of California, brought a group of these bats to the California Academy of Sciences. He had captured 15 of them a few days previously (April 29) on Isla Blanca, near Guaymas, Sonora, Mexico. Several died during the trip by car to California and the dozen survivors were in rather

poor condition by May 4. Since their natural food is believed to consist principally of small fish and crustaceans secured in the Gulf of California these bats were given whitebait (*Spirinchus starksi*), a small, smelt-like fish of the family Osmeridae that is commonly sold in markets along parts of the Pacific coast. Force-feeding was necessary for a few days. It was found that a single fish, whose average weight was slightly less than 12 grams, was sufficient food for one bat per night. The fish, which were kept frozen until used, were cut into slices about one-quarter of an inch in thickness before they were placed in the cage containing the bats each evening. Since the bats were unattended on Saturdays and Sundays they were given a generous supply of mealworms, which they appeared to like, on Friday evenings. This eliminated problems involved in keeping fish at room temperature for several days.

Eight of the twelve bats survived and within several weeks appeared to be in fair health. Four of these were given to the writer. Although three of them succumbed during the following August, one is still alive at the time of this writing.

Longevity.—Cockrum (1956) has given an excellent summary of most of the published records pertaining to longevity in bats. Some additional records

TABLE 1.—*Longevity of bats in captivity*

DATE OF CAPTURE	DATE OF DEATH	ALIVE AS OF APRIL 1, 1957	PERIOD OF SURVIVAL IN CAPTIVITY
	Myotis yumanensis saturatus		
Aug. 20, 1953	Aug. 30, 1954		1 yr., 10 days
July 3, 1954	—	alive	2 yrs., 8 mo., 29 days
July 3, 1954	Escaped on July 16, 1956		2 yrs., 13 days
	Myotis sodalis		
Jan. 27 1952	Dec. 1, 1953		1 yr., 10 mo., 4 days
	Pizonyx vivesi		
Apr. 29, 1954	—	alive	2 yrs., 11 mo., 3 days
	Lasiurus cinereus		
Oct. 31, 1955	Jan. 29, 1957		1 yr., 2 mo., 29 days
	Antrozous pallidus pacificus		
June 14, 1948*	Sept. 21, 1956		8 yrs., 3 mo., 7 days
Jan. 15, 1950	—	alive	7 yrs., 2 mo., 17 days
Oct. 27, 1950	—	alive	6 yrs., 5 mo., 5 days
June 9, 1952	Dec. 10, 1955†		3 yrs., 6 mo., 1 day
June 9, 1952	Dec. 8, 1955†		3 yrs., 5 mo., 29 days
June 9, 1952	Dec. 4, 1955†		3 yrs., 5 mo., 25 days
June 9, 1952	Dec. 4, 1955†		3 yrs., 5 mo., 25 days
June 9, 1952	Sept. 15, 1955		3 yrs., 3 mo., 6 days
Aug. 16, 1954	—	alive	2 yrs., 7 mo., 16 days
Jan. 29, 1955	—	alive	2 yrs., 2 mo., 3 days
	Tadarida mexicana		
Oct. 24, 1952	—	alive	4 yrs., 5 mo., 8 days

* Born in captivity on this date.

† Death is believed to have resulted from being subjected to too low a temperature (36.5°F.).

are provided by Verschuren (1956). Although no special attempt was made by the writer to determine how long various species of bats can survive in captivity, certain data were obtained which are given in Table 1. Only records obtained from bats that were kept for more than one year are listed. With one exception, noted, all of the bats were captured as adults.

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COLOR VARIATION AND MOLT IN *MORMOOPS MEGALOPHYLLA*

By Denny G. Constantine

Collections of *Mormoops megalophylla senicula* (Rehn), made at Frio Cave, 9 mi. S Concan, Uvalde Co., Texas, have provided a basis for the following review of color variation and molt in this form. Comparative specimens from within the range of *Mormoops m. megalophylla* Peters are considered of passing interest. It is not the intent of this paper to contest or confirm the taxonomic status of these forms, although indications are that this group deserves further taxonomic consideration. Therefore, the term *senicula* is used for convenience only, and the color descriptions must be considered primarily those derived from specimens collected at a single locality. Moreover, evidence suggests that ammonia fumes in Frio Cave bleach the pelage of two other species, so color values assigned here may not be applicable elsewhere.

The author has presented evidence in a previous paper (Jour. Mamm., 38: 461–466, 1957) that adult *Tadarida brasiliensis mexicana* (Saussure) and *Myotis velifer incautus* (J. A. Allen) undergo a single molt each year, at which time an apparently faded coat is replaced by a darker, fresh coat. The same may be true of *Mormoops*, but in the absence of year-round collections, this cannot be substantiated. Therefore, for convenience only the term "faded coat" is used to designate the light pelage, and "fresh coat" is used in reference to the dark, fresh coat.

Immature animals were so designated by size, epiphyseal development of the finger joints, cranial development and tooth wear. Color values are from Ridgway (COLOR STANDARDS AND COLOR NOMENCLATURE, 1912).

Specimens examined.—Of the 320 *Mormoops* included in this analysis, 308 were taken at Frio Cave in August, 1944 and December, 1946. In 1944, 50 specimens were prepared as study skins; in 1946, 246 individuals were closely examined and banded, 12 others being prepared as study skins. A series of 8 skins, collected by H. S. Gentry on January 8, 1935 at Carimechi, Rio Mayo, Chihuahua, Mexico, and 4 skins collected in Texas by Jack Couffer were used as comparative material.

Distribution of pigment in hair.—The pigment of dorsal and mid-ventral hairs occurs in a series of four to five bands or zones. These zones, from tip to base of hair, are: (1) lightest and shortest zone; (2) darkest zone, generally intermediate in size between zones 1 and 3; (3) widest zone, lighter than zones 2 and 4, darker than zone 1; (4) usually the same color and approximate size as zone 2, occasionally slightly lighter; (*X*) a zone apparently produced by a blending of the overlapping borders of zones 2 and 3; this band varies greatly in width and is usually not evident in the fresh coat. It is in zone *X* that the brightest colors occur.

Because of the heterogeneous appearance of the pelage of this species it is impossible to present an accurate simplified description of the color differences occurring in faded and fresh coats of adults and coats of immature individuals except to state that these are, respectively, light, dark and darker. However, an accurate analysis must be based on more substantial values, and it was decided that the investigation could proceed only by recording the colors of all hair zones. To facilitate discussion, the color value for each zone, from tip to base of hair, has been fitted in a formula:

zone 1 / zone 2 / zone *X* / zone 3 / zone 4

Presentation is further simplified in Table 1.

Pelage of adults.—The presentation of color variation (Table 1) in faded pelage is based on 8 males and 1 female, collected at Frio Cave in August. The

TABLE. 1—*Color variation in Mormoops megalophylla senicula Rehn*

ZONE	FADED COATS OF ADULTS		FRESH COATS OF ADULTS		COATS OF YOUNG	
	Dorsum	Venter	Dorsum	Venter	Dorsum	Venter
1	pale ochraceous-buff	pale ochraceous-buff to cinnamon-buff	light buff to pale ochraceous-buff	light buff to cinnamon-buff	light buff	light buff
2	snuff brown to bister	snuff brown to cinnamon	cinnamon-brown to Prout's brown	buffy-brown to Saccardo's umber	mummy-brown	buffy brown
x	Sayal brown to snuff brown	pinkish buff to vinaceous-cinnamon	pale ochraceous-buff to cinnamon-brown	pinkish buff	pale ochraceous buff	pale ochraceous buff
3	pinkish buff	pinkish buff to light pinkish cinnamon	pale ochraceous buff to pinkish buff	pinkish buff	pale ochraceous buff	pale ochraceous buff
4	snuff brown to bister	snuff brown to cinnamon	cinnamon-brown to Prout's brown	buffy brown to Saccardo's umber	mummy-brown	buffy brown

faded portion of the coat of a molting female, collected at the same time, is more yellow than the others, having the following color formula: Dorsum—pale ochraceous-buff/ cinnamon-brown/ ochraceous-tawny/ cinnamon-buff/ cinnamon-brown; Venter—cinnamon-buff/ tawny-olive/ cinnamon-buff/ cinnamon-buff/ tawny-olive. Six of the specimens prepared at Frio Cave in August are males in fresh coat. Seven females and one male, taken there in December do not differ in color from these specimens. On December 5, 1943, Jack C. Couffer collected a similar adult male at Valdena Farms Sinkhole, 20 mi. N D'Hanis, Medina Co., Texas. All agree with the color of seven individuals of the Chihuahua series (4 males, 3 females) taken in January. Excepting one individual, all 246 *Mormoops* examined at Frio Cave during the December banding operations were tentatively considered within the range of fresh adult pigmentation or were immature. The exception is an adult male, collected and prepared because of its aberrant intense cinnamon coloration. Its color, brighter than summer specimens, is: Dorsum—cinnamon-buff/ warm sepia/ pinkish cinnamon/ cinnamon-buff/ warm sepia; Venter—cinnamon/Sayal brown/ cinnamon/ cinnamon/ Sayal brown. A second extremely bright winter specimen is among the Chihuahua series. Its color formula on both dorsal and ventral surfaces is ochraceous-buff/ snuff-brown/ buckthorn brown/ buckthorn brown/ snuff brown.

Pelage of young.—No apparent immature specimens were observed or collected during the August visit to Frio Cave. However, one male and two

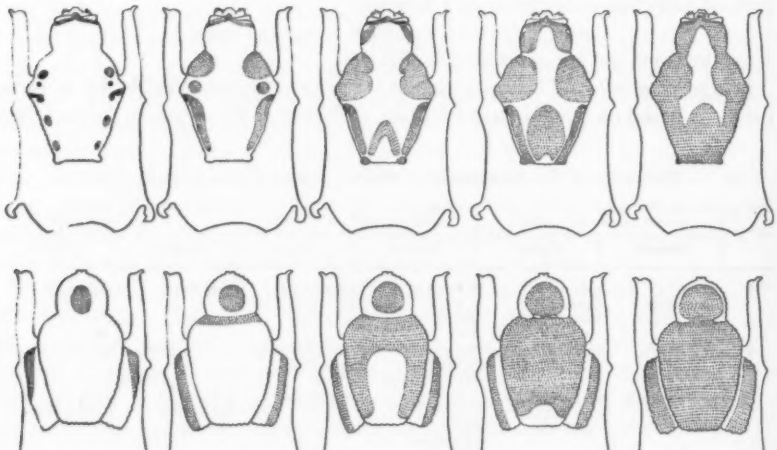

FIG. 1.—Molting sequence in *Mormoops megalophylla senicula*. Upper row: dorsal surface. Lower row: ventral surface. New pelage appears in stippled areas. Molting progresses from left to right.

females were prepared as study skins in December. An immature female was collected by Jack C. Couffer in November, 1943 at Valdena Farms Sinkhole. On December 5, 1943 Couffer collected an immature male at the same locality. On October 29, 1943 he collected an immature individual at Rattlesnake Cave, about 200 yards from Ney Cave, 20 mi. N Hondo, in Medina Co., Texas. All of these specimens agree with the color assignments for immatures, presented in Table 1.

Molt of adults.—Molting individuals are present in the Frio Cave series, collected in August, but none of the other specimens was molting. The sequence of adult pelage replacement, presented in Fig. 1, was established on the basis of 16 male and 11 female skin specimens. The lighter coat is replaced by the darker, fresh coat, the dorsal and ventral pelages being replaced concurrently.

Communicable Disease Center, U.S. Public Health Service, Carlsbad, New Mexico. Received March 5, 1957.

MAMMALS OF THE MEXICAN STATE OF GUERRERO, EXCLUSIVE OF CHIROPTERA AND RODENTIA

By William B. Davis and Paul W. Lukens, Jr.

In a previous issue of this Journal (vol. 38: 1–14), Lukens and Davis published on the 29 species of bats known to occur in Guerrero. The present paper deals with the marsupials, insectivores, lagomorphs, carnivores, edentates and artiodactyls accumulated from that state since 1942 mainly through our summer field studies and the assistance of Joaquin Villanueva. Certain specimens in the Instituto de Biologia (IB), the Biological Surveys Collection (BSC), the U.S. National Museum (USNM), the University of Michigan Museum of Zoology (UMMZ), the American Museum of Natural History (AMNH), and the Walla Walla College Museum of Natural History (WW) were examined by Davis during the course of the study. For the privilege of examining these specimens we are grateful to Sr. Bernardo Villa R., Dr. John W. Aldrich, Miss Viola S. Schantz, Dr. David H. Johnson, Dr. W. H. Burt, Mr. George G. Goodwin, and Dr. E. S. Booth. Special acknowledgment is due the officials of the Mexican Dirección General Forestal y de Caza who made our field work possible. Unless otherwise indicated, all specimens examined are in the Texas Cooperative Wildlife Collection.

Although special effort was made to acquire specimens of all known kinds of mammals in the state, we failed to collect *Spilogale pygmaea* Thomas, *Felis pardalis nelsoni* Goldman, and *Sylvilagus insonus* (Nelson), each of which seems to be rare in the state.

The shrew *Cryptotis guerrerensis* Jackson is submerged as a synonym of *Cryptotis mexicanus goldmani* (Merriam); *Lutra annectens latidens* Allen is considered a synonym of *L. a. annectens* Major; *Spilogale anguistifrons* Howell

is placed as a subspecies of *S. gracilis; Jentinkia sumichrasti latrans* is described as new; and *Odocoileus acapulcensis* (Caton) is removed from the species *O. virginianus*. New records for Guerrero are *Megasorex gigas* (Merriam), *Mustela frenata leucoparia* (Merriam), *Lutra a. annectens* Major, *Felis wiedi glaucula* Thomas, *Felis concolor mayensis* Nelson and Goldman, and *Canis latrans vigilis* Merriam.

ACCOUNTS OF SPECIES

Didelphis marsupialis californica Bennett.—Our adult specimens agree well with the description of *californica* despite the fact that the ratio of the nasals to the condylobasal length for one adult female (50.66) approaches that of *D. m. tabascensis*. The nasals of our specimens are definitely truncate posteriorly, and the tails of the two adult females are actually and relatively shorter than those reported for *tabascensis* (ratio of length of tail to length of head and body, 85 and 90).

Two of our specimens are adult females. The larger is in the gray phase; the smaller, in the black phase. The former has the basal one-half of the tail black; the latter, two-thirds black. The hind toes and ears in both are all black. The larger female, collected June 17 at Acahuizotla, was carrying 12 young in her pouch. Two of the other three specimens collected June 20 are about three months old; the third, collected in August, is about half grown. This suggests at least two litters a year in this area.

Measurements, two adult females: Total length, 811, 775; length of tail, 376, 345; length of hind foot, 51, 60; height of ear, 49, 42; length of skull, 103.2, ——; length of nasals, 45.0, 43.9; zygomatic breadth, 52.5, ——; postorbital width, 10.6, 10.7; length of maxillary tooth row, 39.7, 40.9 mm. Weight, 1716, 1130 gm.

Specimens examined, 12 as follows: Acahuizotla, 2800 ft., 3; Agua del Obispo, 3300 ft., 1; Acapulco, 6 (BSC); 30 km. N Acapulco at El Treinte, 500 ft., 1; El Limón, 2500 ft., 1 (BSC).

Marmosa canescens canescens Allen.—The murine opossum appears to be widely distributed on the Pacific slopes of Guerrero in the Tropical Deciduous and Thorn forests below an elevation of 3000 feet. But they seemingly are not abundant if our trapping success is any measure.

Four of our six specimens, captured in August and September, are half-grown young. One was captured in a bean patch; one in the tangled roots of a tree; two on the road. The subadult female, captured in November, was found in a pile of corn stalks; the adult male, captured in April, was in a dry rocky stream bed.

Measurements of a subadult female from Acahuizotla, a subadult female from Chilpancingo, and an adult male from Acahuizotla, respectively: Total length, 200, 233, 240; length of tail, 110, 125, 135; hind foot, 18, 17, 20; basilar length, 25.7, 27.5, 29.6; cranial width, 11.1, 11.6, 12.5; interorbital width, 4.4, 4.6, 5.1; postorbital constriction, 7.4, 6.9, 7.1; length of nasals, 12.4, 12.8, 15.1; length of maxillary tooth row, 11.5, 12.5, 12.7 mm.

Specimens examined, 11 as follows: *Ca.* Acahuizotla, 2800 ft., 4; Chilpancingo, 1 (UMMZ); Nejapa, 3000 ft., 1; Acapulco, 1 (BSC); Tlapa, 3000 ft., 3 (BSC); Xochihuehuetlán, 2800 ft., 1 (BSC).

Megasorex gigas (Merriam).—Previous records of this large, long-tailed shrew are from (1) just below the mouth of the canyon at Milpillas, 3850 ft., near San Sebastian, Jalisco, the type locality, where E. W. Nelson trapped three specimens near the upper limits of the "Arid Upper Tropical" zone March 14–15, 1897, and (2) from Los Reyes, 4800 ft., Michoacán, where the fourth specimen was taken by Nelson and Goldman in February, 1903. Goldman (1951) characterizes the Los Reyes site at "near the boundary between the Lower Austral and Arid Upper Tropical Zones but . . . preponderantly tropical in zonal character."

On November 6, 1955, Joaquin Villanueva captured an adult "female?" of this species in "el Cañon de Acahuizotla" in Central Guerrero, thus extending the known range of this shrew

some 220 miles southeastward from Los Reyes and 375 miles for San Sebastian. Acahuizotla is situated slightly below the juncture of the Tropical Deciduous Forest and the Pine-Oak Forest.

As pointed out by Merriam (1897) and Hibbard (1950), *Megasorex* resembles *Notiosorex* in having only three unicuspids in each upper tooth row and a total of 28 teeth. The large size, proportionately long tail, non-excavated upper molars, and heavy rostrum, however, readily separate it from the known forms of the latter genus.

Comparative measurements of four specimens of *gigas* from Jalisco and Michoacán in the Biological Surveys Collection (88012, type [after Merriam, 1897]; 88011, skin only; 88010, skull only; 125896, skin and skull) and the specimen from Guerrero, in parentheses, are respectively: Total length 128, 127, —, 130 (140); tail, 45, 39, —, 43 (50); hind foot, 15, 15.3, —, 15.6 (15.5); greatest length of skull, 23, —, —, 23.9 (23+); cranial width, 10.5, —, —, 10.4 (10+); maxillary breadth, —, —, 7.0, 7.0 (7.0); length of palate from tip of incisors, —, —, 11.1, 11.3 (11.4); length of upper tooth row to tip of incisor, —, —, 10.1, 10.6 (11.1); interorbital width, —, —, 5.3, 5.4 (5.7); width of rostrum, —, —, 3.1, 3.0 (3.2); length of mandibular tooth row to tip of incisor, —, —, 9.5, 9.7 (10.0) mm.

Specimen examined, 1, from 2 km. SE Acahuizotla, 2800 ft.

Sorex saussurei saussurei Merriam.—Compared with *Sorex veraepacis,* the only other long-tailed shrew known from Guerrero, the Saussure shrew is smaller (weight about 5 grams); upper-parts duller brown, tending toward sepia; underparts lighter, almost gray. Cranially, *saussurei* differs from *veraepacis* in having a relatively larger and narrower mesopterygoid fossa, a narrower, flatter cranium with the brain case rounder laterally, and a shorter unicuspid tooth row (Jackson, 1928).

Cranial measurements of Guerreran specimens of *saussurei* are somewhat smaller than those reported by Jackson (*op. cit.,* p. 163) for animals from other parts of the range. A young adult male weighed 4.3 gm.; a young adult female, 5.0 gm. They have the following measurements, respectively: condylobasal length, 17.4, 17.5; breadth of braincase, 8.5, 9.0; interorbital width, 3.8, 4.1; palatal length, 7.3, 7.1; length of maxillary tooth row (I^2–M^2) 6.6, 6.4; maxillary width across M^2, 5.0, 5.0 mm.

Our two specimens from Omiltemi were caught in snap traps set under logs on a rather open, pine-covered slope that had a good ground cover of humus and dead pine needles. Judging from our trap records, they seemed to associate with *Reithrodontomys sumichrasti.*

Specimens examined, 5, as follows: Mountains west of Chilpancingo, 9600–9800 ft., 2 (BSC); Omiltemi, 8000 ft., 1 (BSC); 2 mi. W Omiltemi, 7900 ft., 2.

Sorex veraepacis mutabilis Merriam.—This distinctive, clove-colored, long-tailed shrew occurs in the higher parts of the Sierra Madre del Sur of Guerrero in the Pine-Fir forest association. Our specimen from 2 mi. W Omiltemi was captured in a metal live trap set on a shady, fern-covered, rocky hillside above a limestone sink that had a deep layer of damp humus and leaf litter. Numerous small galleries about 20 mm. in diameter and from two to six inches beneath the surface were probably occupied by shrews of this species. The specimen from west of Mazatlán was flushed from under a fallen log and captured by hand. The area in which it was found was a rather open brush community, with little ground litter, in the pine-oak forest.

Only one of the three specimens known from Guerrero has a complete skull, measurements of which follow: condylobasal length, 19.7; palatal length, 8.0; cranial breadth, 10.0; least interorbital width, 4.6; breadth of maxillary tooth rows (across M^2), 5.6; length of upper tooth row (posterior border of I^1 to posterior border of M^2), 7.6 mm. These measurements are noticeably larger than the largest reported by Jackson (1928) for *mutabilis* from Oaxaca. It is likely that the Guerreran population is subspecifically distinct. Weight of an adult male was 9.0 gm.; of a young adult female, 6.0 gm.

Specimens examined, 3, as follows: 5 mi. W Mazatlán, 8000 ft., 1 (skin only); 2 mi. W Omiltemi, 7800 ft., 1; Omiltemi, 1 (BSC).

Cryptotis mexicana goldmani (Merriam).—In 1895 Merriam described *goldmani* on the basis of five specimens taken December 21–24, 1894, at elevations of 9600–10000 feet in the mountains west of Chilpancingo. The type is recorded (Merriam, 1895) as a young adult male. Three of the other four specimens which we have examined have faint indications of wear on the molars and are judged to be young animals.

In 1933, Jackson described *Cryptotis guerrerensis* on the basis of six specimens taken May 17–24, 1903, near Omiltemi, elevation near 8000 feet, a locality also in the mountains west of Chilpancingo. The type and three of the other specimens which we have examined have moderately worn teeth and are therefore fully adult. Jackson (1933) placed *guerrerensis* in the *mexicana* group and reported that it differs from *goldmani* as follows: (1) larger size, with distinctly larger feet; (2) skull larger and much heavier; (3) interorbital area relatively and actually wider; (4) rostrum wider and heavier; (5) molariform teeth slightly wider.

In December, 1954 and 1956, we collected four specimens of this (*mexicana*) group near Omiltemi which, when compared with three paratypes of *goldmani* and three of *guerrerensis*, lead us to the conclusion that the differences ascribed to *guerrerensis* are not genetic, but are due to age and season. Merriam's *goldmani* are subadult animals with slightly worn teeth, as are our four specimens, all of which were taken in December. Jackson's *guerrerensis* are older animals taken in May, and have considerable wear evident on all teeth. Examination of measurements (Table 1) clearly indicates, to us, that no significant differences exist in these three samples. Our four specimens are slightly blacker than the other two samples, but we attribute this to fading of the older specimens. Consequently, we are of the opinion that *guerrerensis* is a synonym of *goldmani*.

Our trapping experience indicates that *goldmani* prefers a habitat with considerable ground litter. Traps set for them anywhere but under fallen logs or pieces of sawed lumber failed to take them. In one instance, two were caught during the same night in snap traps under the same log. One was caught in a metal live trap set beside a tunnel that was under a slab of lumber. This burrow was about an inch in diameter and so close to the surface that the lumber formed the roof. One such burrow was traced for 60 feet, as it led from one board to another, on a brushy slope with a deep layer of humus and leaf litter. In no place was it more than four inches beneath the surface. Merriam (*op. cit.*) stated that the original series of *goldmani* was collected in damp thickets among fir trees.

Specimens examined, 10, as follows: Mountains west of Chilpancingo, 9600–9800 ft., 3 (BSC); Omiltemi, 8000 ft., 3 (BSC); 2 mi W Omiltemi, 7900 ft., 4.

Canis latrans vigilis Merriam.—Coyotes are not common in Guerrero. All verbal accounts we have of them are from the Balsas Basin and the drier, open valleys in the vicinity of Chilpancingo. A young adult male from near Coaztlahuacan, a small village about 10 km. south of Mochitlán in an open valley on the east side of Cerro Texquilquitemi, appears to be referable to *vigilis* on the basis of cranial measurements and small teeth. This is the first record we have for the state.

Cranial measurements, using Young and Jackson's (1951) techniques, follow: Condylobasal length, 174; palatal length, 87.6; squamosal constriction, 57.7; zygomatic breadth, 95.3; interorbital breadth, 31.6; length of maxillary tooth row, 80.2; length of Pm^4, 16.7; length of M^1, 12.5; width of M^1, 14.7; length of M_1, 21.0 mm.

Specimen examined, 1 from near Coaztlahuacan, approx. 4000 ft.

Urocyon cinereoargenteus colimensis Goldman.—Next to the coati, the gray fox seems to be the most common carnivore in Guerrero. We have no records of its occurrence in the pine-fir forest above the 6000 foot contour.

The race *colimensis* is described (Goldman, 1938) as usually smaller and darker than *scotti* of the southwestern deserts of the United States and adjacent Mexico. The most obvious difference, when compared with specimens of *scotti* from Arizona and Trans-Pecos Texas, is in color; *colimensis* is much blacker dorsally and less yellowish or fulvous on the sides and neck. That *colimensis* is not smaller, as judged by weight, is evident from weights of an adult female,

TABLE 1.—*Comparative measurements of Cryptotis from central Guerrero*

	goldmani (paratypes)				*guerrerensis* (paratypes)				SPECIMENS IN TCWC			
		Type			Type							
No.	70243	70244	70245	70247	126895	126896	126947	127500	5574	5575	5576	5665
Sex and age	♀ Sad	♂ Sad	♀ Sad	♂ Sad	♀ Ad	♂ Ad	♂ Ad	♂ Ad	♂ Sad	♀ Sad	♀ Sad	♀ Sad
Date	12/21	12/23	12/23	12/24	5/17	5/17	5/23	5/24	12/26	12/27	12/27	12/25
Total length	100	100[4]	93	104	110	106	113	102	105	92	99	96
Length tail	30	28	26	29	32	31	29	28	32	29	29	28
Length hind foot	13	13	13	13.5	14.5	14.5	13.5	14	13	14	14	14
Condylobasal length	[3]	18.9	[3]	19.5	20.0	18.9	19.6	—	19.4	19.5	19.3	19.5
Palatal length	—	8.2	—	8.2	8.6	8.5	8.3	8.3	8.5	8.5	8.5	8.3
Cranial breadth	—	10.0	—	9.8	10.4	10.2	10.3	—	10.3	10.0	10.2	10.1
Interorbital breadth	—	4.9	—	4.7	5.3	5.2	5.1	5.0	5.1	5.0	5.3	5.3
Maxillary breadth[1]	—	5.7	—	5.6	6.6[5]	5.7	5.6	5.7	5.8	5.7	5.8	5.7
Tooth row[2]	—	7.2	7.1	7.1	7.4	7.1	7.2	7.0	7.3	7.2	7.2	7.2

[1] Measured across M^3.

[2] Measured from posterior border of first incisor to back of last molar.

[3] Skull fragmented.

[4] External measurements after Merriam; skull measurements made by Viola S. Schantz.

[5] Measurements after Jackson. In measuring maxillary breadth, Jackson measured across the maxillary processes. We have measured across M^3. This explains his measurement of 6.6 as compared with our 5.7..

3157 grams, and an adult male, 3895 grams. Available weights of adult *scotti* are: one female, 2609 grams; three males, 2156, 2760, and 3632 grams. We can detect no significant differences in cranial measurements.

Specimens examined, 10, as follows: Acahuizotla, 2800 ft., 4 (one skull only); Agua del Obispo, 3300 ft., 1; 2.5 mi. S Almolonga, 5600 ft., 2 (one skull only); 15 km. S Chilpancingo, 4300 ft., 1; 1 mi. S Tierra Colorada, 900 ft., 1; Tlapa, 3000 ft., 1 (BSC).

The unexpected discovery of *Jentinkia sumichrasti* in the Sierra Madre del Sur of central Guerrero and the subsequent efforts to determine the identity of that population led us to review the present knowledge and status of this species in Mexico. The nominate form was described by Saussure in 1860 on the basis of specimens from Mirador, Veracruz. In 1932, Nelson and Goldman described the subspecies *campechensis* from the lowlands of Campeche and Yucatán and stated that it is similar to *sumichrasti* of the mountains of Veracruz, "but considerably smaller; skull smaller, more delicate in structure." Subsequently Goodwin (1956) described *oaxacensis* from the district of Juchitán, southern Oaxaca.

In an effort to assemble all of the specimens of *Jentinkia* in American museums we were able to locate and borrow 16 of the 18 known specimens, as follows:

Veracruz: Mirador (USNM 7082/8632, ad♀?, collected in 1866 and now in poor condition); San Andres Tuxtla, 23 mi. N (E. S. Booth, 1759♀ and Ruth Coss, 70♂, skin only, Walla Walla College Mus. Nat. Hist.).

Campeche: La Tuxpena (USNM 181254♀, 181256♀, 181257♂, 180213♂?); Apazote (USNM 108290♂).

Chiapas: N slope Volcan Tacaná (UMMZ 83335♀).

Oaxaca: Tenango (AMNH 14754, old♂); Tres Cruces (AMNH 148776♂, and 148803♂); Tequisistlán (AMNH 148804♂); Guiengola (AMNH 145160♀ ad.).

Guerrero: 2 mi. W Omiltemi, 7900 ft. (TCWC 5157♀); Puentecilla, 2510 m. (IB 2210♀).

Because females are available from most of the above localities and also because their cranial characters vary less with age than do those of males, only females were used in this study of geographic variation. Perusal of Table 2 clearly indicates that on the basis of cranial measurements the specimens from Mirador (Veracruz), Guiengola (Oaxaca), and Volcan Tacaná (Chiapas) are similar in size and proportions and that they are larger than examples from the lowlands of Campeche and the two females from Guerrero. That the animals from Mirador, Guiengola, and Volcan Tacaná are alike is not surprising because each of the last two localities is in or near the mountains that form the Continental Divide in southern Mexico and these mountains in turn join with the Sierra Madre Oriental in which range Mirador is located. Consequently, no important geographic barrier exists to isolate populations at these localities.

The specimen from San Andres Tuxtla is from an area somewhat isolated from the Sierra Madre Oriental. The skull is slightly smaller than that of animals from Mirador, Tuiengola, and Volcan Tacaná, but not significantly so.

Specimens from the lowlands of Campeche and Yucatán have crania that are noticeably smaller than those of the group mentioned above.

The crania of specimens from Omiltemi and Puentecilla, Guerrero, an area fairly well isolated from the mountains to the east, are distinctly smaller than ones from the mountains of Veracruz, Oaxaca, and Chiapas. They are more nearly the size of specimens from the lowlands of the Yucatán Peninsula. External measurements of the only skin examined, however, are larger and the pelt is more heavily suffused with black. Consequently, it appears to us that three recognizable populations of *sumichrasti* occur in Mexico, as follows:

(1) *J. s. sumichrasti* (Saussure) which occupies the Sierra Madre Oriental from central Veracruz southward along the Continental Divide at least to Volcan Tacaná on the Guatemalan border, and the highlands near San Andres Tuxtla. These animals have large crania, with heavy rostrum and large cheek teeth. We have not examined the type of *J. s. oaxacensis* Goodwin, but the other Oaxacan specimens are, in our opinion, referable to this race. Good-

win (1956) comments that, compared with *campechensis*, the Oaxacan specimens are larger, with a heavier rostrum and stronger dentition. This combination of features characterizes the nominate race. Consequently, we are of the opinion that *oaxacensis* is a synonym of *sumichrasti*.

(2) *J. s. campechensis* Nelson and Goldman, which inhabits the lowlands of Campeche and Yucatán, is the smallest member of the species in México. Both the skull and the cheek teeth are smaller than in *sumichrasti*.

(3) An unnamed race which occupies the higher parts of the Sierra Madre del Sur in Guerrero for which we propose the name

Jentinkia sumichrasti latrans subsp. nov.

Type.—TCWC No. 5157, skin and skull, adult female, from 2 miles west of Omiltemi, 7900 feet, Guerrero; collected June 12, 1953, by George W. Griffith, original No. 231.

Paratype.—IB No. 2210, from near Puentecilla, 2510 m., Guerrero.

Diagnosis.—A small form similar to *J. s. campechensis* in size of cranium, but rostrum broader and interorbital width slightly greater; pelage longer. Differs from *J. s. sumichrasti* in much smaller cranium with narrower rostrum, narrower interpterygoid space, and lighter dentition.

Measurements.—See Table 2. In the paratype the ear measured 53 mm.; weight was 900 gm.

Remarks.—The type specimen was collected at night in the dense forest near Omiltemi. Its barking cry could be heard a long way, and we trailed it for several miles before it was finally located high in a tree. Another individual was present in the same tree, but it quickly

TABLE 2.—*Measurements of female specimens of Jentinkia sumichrasti from Mexico*

NO.	VERACRUZ 7082/8632	VERACRUZ 1759	OAXACA 145160	CHIAPAS 83335	CAMPECHE 181256	CAMPECHE 181254	GUERRERO 5157	GUERRERO 2210
Age	Ad.	Ad.	Ad.	Ad.	Sad.	Ad.	Ad.	Ad.
Total length	—	818	905	822	891	880	967	955
Length of tail	480 est.	423	490	423	459	455	520	500
Length of hind foot	83	85	62?	82	82	77	86	91
Condylobasal length	84	79.5	82.6	85.0 est.	75.9	76.9	80.0	79.6
Zygomatic breadth	56.3	52.2	57.0	55.0 est.	48.0	49.0	48.7	51.5
Cranial breadth	35.2	35.4	35.9	38.0 est.	35.0	33.7	34.2	35.0
Breadth of rostrum over canines	16.3	16.4	16.7	15.6	14.0	14.5	15.1	15.2
Interorbital breadth	18.2	17.4	18.0	—	15.2	16.1	16.0	16.0
Length of maxillary tooth row	31.1	31.6	32.7	32.0	29.2	30.5	30.3	29.7
Crown length Pm^4	6.8	6.6	6.5	6.8	6.6	6.4	6.6	6.0
Crown width Pm^4	5.2	5.5	5.2	5.8	4.7	5.3	5.0	5.2
Crown length M^1	6.0	6.0	6.2	6.1	5.5	5.5	5.6	5.6
Crown width M^1	8.1	8.1	8.0	8.2	7.0	7.4	7.7	7.3

disappeared after the first gunshot. It would seem that *Jentinkia* is rare in this area because the native guide with us, a resident of Omiltemi, did not recognize the animal.

Bassariscus astutus bolei Goldman.—This subspecies was described on the basis of a single adult male taken near Chilpancingo in February, 1940. In the intervening years only one additional specimen has become available, a male taken in January, 1955. The validity of *bolei* cannot be established from the material at hand because the extent of individual variation cannot be determined. When compared with representatives of the race *astutus* from the states of Morelos and Puebla, the Guerreran specimens differ only slightly (see Table 3). Consequently, we are currently of the opinion that *bolei* is weakly differentiated from *astutus* and additional material may reveal it to be inseparable.

Specimen examined, 1, from near Acahuizotla, 2800 feet.

TABLE 3.—*Comparative measurements of male Bassariscus from Mexico*

SUBSPECIES	*B. a. bolei*		*B. a. astutus*		
No.	Type	5615	4954	4956	2837
Locality	Guerrero	Guerrero	Morelos	Morelos	Puebla
Total length	850	740	852	841	835
Tail	420	370	408	409	400
Hind foot	80	75	79	81	85
Condylobasal length	84.5	81est.	85.4	86.2	87.2
Zygomatic breadth	56.5	47est.	60.5	53.6	59.0
Rostral breadth (over canines)	16.7	—	17.1	16.5	17.7
Interorbital breadth	16.0	17est.	18.1	17.5	17.3
Length maxillary tooth rows	31.7	32.1	33.3	32.5	33.5
Crown length Pm^4	7.0	7.8	7.9	7.8	7.5
Crown width Pm^4	5.1	5.3	5.1	5.1	5.4

Procyon lotor hernandesi Wagler.—Raccoons are well known to hunters in Central Guerrero, but the population was low during the course of our study. By special effort over three years we collected seven specimens, four subadult males, two young males, and one subadult female. Although all available Guerreran records are from the Tropical Deciduous and Thorn forest associations, raccoons probably are widely distributed over the state below 6000 feet wherever permanent water is available.

Cranial measurements of two males and one female (in parentheses): Greatest length, 120, 112.4 (119.6); condylobasal length, 113.3, 107.8 (104.5); zygomatic breadth, 74.9, 65 (64); least interorbital width 23.7, 21.6 (20); least width of palatal shelf, 16.2, 16.4 (14.9); alveolar length of maxillary tooth row, 41.4, 42.3, (39.5); crown length of Pm^4, 8.2, 8.4 (8.0); crown width of Pm^4, 8.2, 8.4 (8.5) mm.

Specimens examined, 10, as follows: *Ca.* Acahuizotla, 2800 ft., 7; Papayo, 220 ft., 2 (BSC); Tlapa, 3000 ft., 1 (BSC).

Nasua narica molaris Merriam.—The latest review of the Central American coatis (Hershkovitz, 1951) treats them as three geographic races: (1) a pale form, *yucatanica,* occupying the Yucatán Peninsula, (2) a dark form, *narica,* occurring from Central Veracruz and the Isthmus of Tehuantepec southward into Panama, and (3) another pale form (*molaris*) occurring generally north of the Isthmus into southern United States. Earlier, Burt and Hooper (1941) pointed out the futility of trying to differentiate the many named subspecies

in Central America on the basis of cranial characters. Unfortunately, neither treatise presents measurements to substantiate the conclusions drawn. Although Merriam (1902) asserted that *molaris* differs from *narica* in having "molariform teeth, particularly the upper ones, very much larger and more massive," he, too, gave no measurements to substantiate the statement. Until a revisionary study of the entire species dictates otherwise, we are accepting Hershkovitz's (*op. cit.*) concept of geographic variation of this species in Mexico.

On the basis of numbers collected, the coati is the most common carnivore in central Guerrero. It seems to prefer heavily wooded canyons, particularly those with streams. Near Acahuizotla, we found four individuals occupying a large nest in a fig tree. The two taken were subadults; the two that escaped were thought to be larger. Our two specimens from near Omiltemi were taken from a group of six or seven that was feeding along a stream in a steep, narrow canyon.

Unlike other Guerreran procyonids, the coati is mainly diurnal; all but one of our specimens were collected during the day. Several were taken in trees. Coatis apparently have a high ecologic tolerance, because in Guerrero they occupy an altitudinal range of 8,000 feet.

A young individual, weighing 1.62 kilos, whose molariform teeth had not yet fully erupted, was collected on June 23; subadults were taken about the same time. A lactating female was collected on June 11.

Because of the general dearth of measurements of coatis in the literature, it seems advisable to place those of selected individuals from central Guerrero on record (see Table 4).

Specimens examined, 15, as follows: Acahuizotla, 2800 ft., 6 (1 in BSC); near Acapulco, 1 (UMMZ); Agua del Obispo, 3300 ft., 3; Omiltemi, 7900 ft., 4 (2 in BSC); Papayo, 200 ft., 1 (BSC). Additional record, Amojileca (Leopold and Hernandez, 1944).

Potos flavus guerrerensis Goldman.—The arboreal kinkajou is a widespread and characteristic carnivore of the lower, more heavily forested parts of the Tropical Deciduous Forest in Guerrero. Our specimens were all shot from trees at night in densely forested canyons. Kinkajous are nocturnal and exceedingly wary, often barking loudly and incessantly when disturbed, and it requires considerable patience and skill to approach within shotgun range of them. Their general habits are well described by Dalquest (1953).

Their breeding habits are not well known. Asdell (1946) reports the breeding season to be April and the number of young per litter, one. Cabrera and Yepes (1940) record the number of young per litter as "uno o dos," but they make no mention of the periods of breeding and parturition. One of our females, collected July 29, contained one embryo about 30 mm. in crown–rump length. Parturition in this instance probably would have been in September. Another female, taken June 11, was lactating and probably gave birth in May. A young male with the last upper molars not yet erupted through the gums and judged to be about three-fourths grown was collected June 21. This animal without doubt was born the previous year and was possibly 9 or 10 months old. These meager data suggest that the young are born from May to September, inclusive.

The only weight of this animal we have is that for the young male, mentioned above, which is 1.32 kilos. Old adults possibly weigh up to 2 kilos, about 7 pounds. For measurements see Table 5.

Specimens examined, 12, as follows: *Ca.* Acapulco, 3 (2 in BSC); Acahuizotla, 2800 ft., 3; 3 km. E Acahuizotla, 2500 ft., 2; Agua del Obispo, 3200 ft., 1; Ometepec, 1000 ft., 2 (BSC); Papayo, 200 ft., 1 (BSC).

Mephitis macroura macroura Lichtenstein.—Hooded skunks appear to be rather uncommon, but nevertheless widespread, in Guerrero below an elevation of 6000 feet. Specimens are available from the Tropical Deciduous Forest near Chilpancingo and from the Desert Scrub of the Balsas Basin. Measurements of our specimens agree well with those of *macroura* recorded by Howell (1901). Our records extend the known range of this skunk as outlined by Hall and Dalquest (1950) onto the Pacific slope of the Sierra Madre del Sur in Guerrero.

TABLE 4.—*Measurements and weights of Nasua narica from Central Guerrero*

NO.	SEX	WEIGHT (kilograms)	TOTAL LENGTH	LENGTH OF TAIL	HIND FOOT	EAR FROM NOTCH	CONDYLOBASAL LENGTH	ZYGOMATIC BREADTH	HEIGHT OF CRANIUM*	DEPTH OF ROSTRUM (behind canines)	INTERORBITAL BREADTH	MAXILLARY TOOTH ROW	CROWN LENGTH P4	CROWN WIDTH P4	REMARKS
5013	♂	—	1031	510	110	35	121.4	78.0	39.0	20.6	28.5	49.0	7.2	7.1	Old; teeth badly worn
5011	♂	—	1200	560	116	40	131.3	77.7	37.3	20.5	29.5	51.9	7.5	7.0	Adults; teeth slightly worn
84017	♂	—	1140	560	110	—	134.2	59.3	35.7	16.6	27.0	50.4	7.7	7.4	
5010	♂	2.44	840	390	90	40	108.6	54.0	32.5	15.5	23.3	45.5	7.5	7.0	Yg.; canines being replaced
5155	♂	1.63	810	395	83	35	103.0	52.6	32.7	13.5	22.7	42.7	7.5	6.8	Yg.; M^1 just emerging; P^{3-4} being replaced
5402	♀	—	—	—	—	—	117.8	61.0	37.0	17.8	28.2	46.5	8.5	7.3	Adult; lactating
5154	♀	2.86	1025	500	90	39	111.0	63.0	34.2	16.3	26.8	43.5	6.6	6.4	Adult; teeth worn
5400	♀	2.27	960	495	95	37	113.7	56.4	34.1	15.3	24.2	46.6	7.8	6.9	Yg.; premolars being replaced

* Measured from palatal shelf to median point over postorbital processes.
84017 (UMMZ); others TCWC.

TABLE 5.—*Measurements of kinkajous from Guerrero*

NO.	BSC 74,683	5156	1413	5015	5399	5327	5328
Sex, Age	♂ Ad.[1]	♂ Old	♂ Ad.	♂ Yg. Ad.	♀ Old	♀ Old	♀ Ad.
Date	2/15	6/18		6/21	6/11	7/29	8/8
	1895	1953	1937	1953	1954	1953	1953
Total length	1050	1050[3]	920	809	—	950	900
Length of tail	535	560	495	415	—	470	420
Hind foot	110	90	95	94	85	80	80
Ear	—	30	—	39	40	35	35
Condylobasal length	89.1	84.1	80.0	77.0	85.6	85.3	82.0
Zygomatic breadth	61.9	54.5	47.5	48.2	59.5	60.4	55.6
Interorbital breadth	22.3	19.1	18.5	17.7	18.8	19.6	19.9
Rostrum across canines	23.7	22.1	19.9	20.9	23.0	22.3	21.9
Mastoidal breadth	46.7	43.1	39.7	40.5	44.5	46.0	41.9
Maxillary tooth row	21.0[2]	25.9	25.8	25.4	26.1	26.3	26.0
Remarks				M^2 erupting	lactating	1 embryo 30 mm.	

[1] Type of *guerrerensis*; measurements after Goldman (1915). His measurement of 110 for the hind foot appears to be erroneous.

[2] Measured from Pm^1 to M^2; others from C – M^2.

[3] External measurements from skin.

A female collected June 23 at Colotlipa contained three embryos 35 mm. in rump–crown length. She weighed 1212 grams. An adult male taken July 6 at Almolonga weighed 965 grams.

Specimens examined, 4, as follows: 2½ mi. S Almolonga, 5600 ft., 1; 1 mi. SW Colotlipa, 2700 ft., 1; 22 km. S Taxco, 4000 ft., 1; El Limón, 2500 ft., 1 (skull only) (BSC).

Spilogale gracilis angustifrons Howell.—Spotted skunks seem to be widely scattered and uncommon in Guerrero. Two species are known from the state: (1) the peculiarly marked *S. pygmaea* on the coastal plain and (2) a larger form in the highlands that has a color pattern almost identical with that of *leucoparia* from central Texas.

The relationships of the spotted skunks are not well understood. Howell (1906) recognized 14 species when he revised the genus 50 years ago. Since then additional specimens have demonstrated intergradation among many of the "species" he recognized. Hall and Kelson (1952), for example, give evidence to support the conclusion that *ambigua, leucoparia, tenuis, arizonae, phenax, microdon,* and *lucasana* are all referable to one species, *S. gracilis*. These are the forms that occur in the United States roughly west of the 100th meridian. These authors also conclude that certainly *ambigua* and *arizonae*, and possibly *leucoparia*, are based upon individual variants in the subspecies *S. g. gracilis*.

Comparison of the one available specimen of *angustifrons* with specimens of *S. gracilis* from Arizona and central Texas convinces us that *angustifrons* should also be assigned to the species *S. gracilis*. The chief differences are ones of size; *angustifrons* is slightly smaller.

Several years ago, one of us (Davis) studied the then available specimens of *Spilogale* in most of the American collections and came to the conclusion that four good species can be recognized: (1) *S. putorius* in eastern United States, (2) *S. ambarvalis* of Florida, (3) *S. gracilis* of western United States and the highlands of Mexico, and (4) *S. pygmaea* of the lowlands of Central America.

The specimen from Guerrero, a young male, has the following measurements: Total length, 310; tail, 110; hind foot, 35; condylobasal length, 45.0; zygomatic breadth, 27.9; mastoidal

breadth, 25.2; cranial width, 12.2; interorbital width, 13.1; palatal length, 15.8; postpalatal length, 23.1; maxillary tooth row, 14.4 mm.

Specimen examined, 1, from near Chilpancingo (UMMZ).

Conepatus mesoleucus nelsoni Goldman.—Hog-nosed skunks are not of common occurrence in Guerrero. In four summers of collecting there we saw one live young animal (about two months old) and the decayed caracasses of two adult animals that had fallen into and drowned in a vat used to make sugar. Present records are from the Pacific slopes of the Sierra Madre del Sur and the narrow coastal plain below an elevation of 3000 feet. They seem to be absent from the Balsas Basin.

Among named races of *mesoleucus*, our adult female from Acahuizotla and a young adult male from Zihuatanejo seem referable to the small *nelsoni* described from Colima. Compared with a similar aged female of *C. m. mesoleucus* from Puebla, the skull of the female from Guerrero is noticeably smaller. Measurements of both (*mesoleucus* in parentheses) follow: greatest length of skull, 68.8 (74.5); condylobasal length, 64.1 (71.1); zygomatic breadth, 46 (est.) (46.6); width of brain case at notch behind zygoma, 34.5 (37.5); mastoidal breadth, 37.0 (42.1); interorbital width across lacrimals, 23.4 (24.4); palatal length, 27.5 (30.6); post palatal length (to foramen magnum), 31.2 (33.5); length of maxillary tooth row, 22.3 (22.8) mm. The skull of the young adult male is slightly smaller than the type, an adult male, of *nelsoni*.

Specimens examined, 5, as follows: Acapulco, 1 (BSC); Acahuizotla, 2800 ft., 1; Ometepec, 1000 ft., 1 (BSC); Tierre Colorado, 900 ft., 1; Zihuatanejo Bay, 1 (UMMZ).

Mustela frenata leucoparia (Merriam).—Although local residents of Guerrero report that "oncitas" are frequently seen, we have been able to procure only one specimen, the first to be reported from the state. This specimen, an adult female, was shot August 15, 1956, while it was pursuing a house rat in one of the houses of Acahuizotla, a small village at 2800 ft. on the Pacific slope of the Sierra Madre del Sur.

Coloration and cranial measurements indicate that this specimen is assignable to *leucoparia* although it tends toward *goldmani* in certain respects, especially in having the black of the head extending nearly to the shoulders and in the presence of a dark spot near each corner of the mouth. It differs markedly from *perotae* in (1) much darker dorsal coloration, with the black color of the head and neck more extensive, and (2) white bridle continuous rather than interrupted. Consequently, it seems likely that *leucoparia* and *goldmani* intergrade in the Sierra Madre del Sur of southern Guerrero and Oaxaca and that the range of *perotae* does not approach the Pacific coast as is suggested by Hall's (1951: 221) map.

Measurements.—Total length, 450; tail, 180. Skull (following Hall's methods): Basilar length of Hensel, 46.3; length of tooth rows, 15.5; breadth of rostrum, 12.1; interorbital breadth, 10.3; orbitonasal length, 15.9; mastoidal breadth, 23.5; zygomatic breadth, 27.5; length of tympanic bullae, 15.2; lateral length of Pm^4, 5.7; depth of skull at posterior border of molars, 12.7 mm.

Lutra annectens annectens Major.—The Central American river otter, the *perro de aqua* of the Mexicans, has long been known to occur on the western coast of México from Nayarit southward, but there apparently are no previous records from Guerrero.

Our specimens seem to agree with the characters outlined by Major (1897) for *L. annectens*. They differ from *L. canadensis* (Texas specimens) as follows: total dentition actually and relatively smaller, less massive; premolars do not interlock or touch when jaws are closed; diastema between second and third lower premolars (none in *canadensis*). Other obvious differences are a flatter, posteriorly expanded brain case, an actually and relatively smaller nasal opening, and larger infraorbiatal foramina.

The large adult male from Guerrero is like the Nicaraguan otter, *L. a. latidens* Allen, in many respects. In his description of this form, Allen (1908) stated: "This form differs from *L. annectens* Forsyth-Major, in its much larger size and in the relatively much greater size of the teeth, the upper premolar-molar toothrow having a length of 37 mm., while the same

measurement in an old male of *annectens* is 31; the oblique length of P^4 is 15 and in *annectens* 13 . . ." His specimen of *latidens*, an adult male, had a total length of 1280 mm.; a tail length of 490 mm.

That Mexican specimens may be as large as *latidens* is evident from our old male. Measurements in the flesh were not taken, but the tanned hide has a total length of 1450 mm.; the tail, 600. The pelt doubtless has been stretched, but even so the animal in the flesh must have equalled in size the type of *latidens*. Cranial measurements of our male compare with those of the type of *latidens* (in parentheses) as follows: length of upper molar-premolar series, 34 (37); length of lower molar-premolar series, 37.2 (37.5); P^4, on outer side, 13 (13); width at middle, 10.5 (10.5); oblique length, 13.8 (15); length of M_1 15.2 (16) (Allen was in error in calling this tooth P_4); width at middle, 8.4 (8); width near posterior border, 8.1 (7.6); length of lower jaw, 76 (72); breadth of condyle, 21.3 (19.2); height at coronoid, 36.5 (33.4); angle to top of condyle, 15.4 (12).

Careful study of the above comparative measurements clearly indicates that Allen's *latidens* is not significantly different from our large male from Guerrero. In fact, in many respects our animal is larger. In only three measurements, length of the upper molar-premolar series, crown length of the first lower molar, and in the oblique length of the upper carnassial, does the Nicaraguan specimen exceed the one from Guerrero. Consequently, two alternative conclusions can be drawn: (1) either the Guerreran otters are referable to *latidens* or (2) the otters of western México, Nicaragua, and Honduras are inseparable. Because the otters from Oaxaca are small like *annectens* the first alternative seems untenable. Consequently, we propose that *latidens* be submerged as a synonym of *annectens* and that *annectens* be regarded as a population of normally small otters with some individuals attaining large size.

Specimens examined, 3, all from the Río Chapolapa near the village Chapolapa, 1000 ft. These are an adult male, an adult female, and a young female in which the third premolar above and the second premolar below are being replaced. Otters were also reported from the Río Azul near Colotlipa and from the streams below Acahuizotla, but we were unable to procure specimens.

Felis onca hernandesi (Gray).—In Guerrero the jaguar seems to be confined to elevations below 2000 feet. Previous records are from Acapulco and Papayo on the costal plain. Our specimen, an adult male, was killed by a local hunter in the Tropical Deciduous Forest a short

TABLE 6.—*Comparative measurements of Felis wiedi from Mexico*

NO.	5614	5160	5019	5645	*glaucula* Jalisco	*oaxacensis* (Type)
Sex	♂ Ad.	♀ Ad.	♀ Ad.	♀ Juv.	♂	♂
Date	5/14 1955	7/14 1953	6/22 1952	Spring 1956	—	8/31 1894
Total length	900	927	800	—	892	910
Length of tail	380	380	320	—	330	368
Hind foot	120	105	105	—	110	130
Ear	40	43	45			
Condylobasal length	91.2	84.9	81.6	69.6	87.0	90.1
Zygomatic breadth	63est.	59.8	57.3	46.2	65.0	67.4
Breadth of brain case	44.7	43.1	41.4	39.3	39.7	44.5
Interorbital width	18.0	16.8	16.9	13.0	16.8	17.9
Length of tooth row C–Pm^4	26.6	25.4	26.2	—	27.2	29.4
Crown length Pm^4	10.5	9.6	11.1	—	11.3	11.6
Weight, kg.	3.0	2.67	2.4			

distance southeast of Acahuizotla. It has the following measurements: Total length (tanned skin), 1820; tail (tanned skin), 530; hind foot (tanned skin), 200; condylobasal length, 209; zygomatic breadth, 152; interorbital width, 44.2; length of nasals (midline), 59.0; greatest width of nasals, 36.1; postorbital width, 43.3 mm.

Specimen examined, 1, from near Chapolapa, 1000 ft.

Felis wiedi glaucula Thomas.—When Goldman (1943) reviewed the margays of Central America he had available a total of 13 specimens which he assigned to seven geographic races. Only two specimens were available from all of western México, both from Los Masos, Jalisco. To these he assigned the name *glaucula*. Two specimens were also available from the eastern drainage of México, one from Cordoba, Veracruz, the other from Cerro San Felipe near Oaxaca City, the type locality of *F. w. oaxacensis*. Therefore, our four specimens from central Guerrero are of considerable interest. On the basis of the elongated rather than rounded rosette, the shorter maxillary tooth row (26.6 as opposed to 29.4 in males), and the shorter hind foot our specimens are assignable to *glaucula*. But in length of tail, condylobasal length, breadth of brain case, and interobital width (see Table 6) they are like *oaxacensis*. Consequently, our specimens are not only geographically but also morphologically intermediate between *glaucula* and *oaxacensis*. We anticipate that when adequate material is available for study the reported differences between these two named populations will be found to be ones of individual variation. Consequently, we choose to refer our specimens to *glaucula*, the older name.

In central Guerrero, the margay, known locally as "tigrillo" or "gato tigrillo," seems to be associated with the pine-oak and pine forests.

Specimens examined, 4, as follows: *Ca.* Acahuizotla, 2800–4000 ft., 3; 2 mi. W Omiltemi, 7900 ft., 1.

Felis concolor mayensis Nelson and Goldman.—In their revision of the mountain lions, Young and Goldman (1946) had no specimens from western México south of Jalisco. Consequently, their map (p. 197) showing the occurrence of *azteca* in Guerrero was based upon geographic probability. Now that specimens are available from Guerrero it is clearly evident that the population there is assignable to *mayensis* rather than *azteca* (see measurements, Table 7). In addition to small size of cranium, the postero-external border of the palate terminates *anterior* (rather than posterior) to M^1 and the small premolar in the male nearly fills the space between the canine and the second premolar. Both of these features are said to be characteristic of *mayensis*.

Unfortunately, external mesaurements of our animals in the flesh were not taken. Measurements taken from the tanned skins are: Total length, 1870 ♂, 1750 ♀; tail 630, 640; hind foot, 270, 210 mm. These approximate the measurements of *mayensis* recorded by Young and Goldman (*op. cit.*), particularly in the length of tail. Tail measurements of *azteca* recorded by these authors are well over 700 mm. even in females.

The cougar probably inhabits the tropical forests of the coastal lowlands in Guerrero as well as the upland areas. Large cat tracks seen by members of our party near a cave on a mountain side below Agua del Obispo (3300 ft.) and near a water hole 5 miles west of Omiltemi (6800 ft.) presumably were made by mountain lions.

Specimens examined, 2, as follows: 3 km. E Acahuizotla, 2800 ft., 1; Xaltianguis, 1600 ft., 1.

Lepus callotis Wagler.—The white-sided jack rabbit is widespread in the central tablelands of southern Mexico, and even though Nelson's (1909: 116) map includes northern Guerrero in its range, he listed no specimens from there.

This rabbit is common in the more arid interior basins, but it is not as common as *Sylvilagus cunicularius*. Like the latter, it is associated with cultivated and pastured areas. Our specimens were taken in cornfields and the adjacent thorn-brush hillsides in the valley of the Río Huacapa near Colotlipa, in an oak-brush pasture near Almolonga, and in an open, cultivated valley near Omiltemi. Apparently these rabbits do not range out of the open basins and valleys onto the more heavily wooded slopes and hilltops.

TABLE 7.—*Comparative cranial measurements of Felis concolor*

	MALES			FEMALES		
	*azteca** (average of 2)	Guerrero	*mayensis** (type)	*azteca** (average of 2)	Guerrero	*mayensis**
Greatest length	208.6	178.0	183.0	176.0	167.0	160.4
Condylobasal length	192.0	165.0est.	163.7	165.3	152.0	147.5
Zygomatic breadth	146.6	127.9	127.7	123.4	110.7	107.9
Width of nasals	20.7	17.6	16.3	15.8	13.4	13.0
Width of palate	30.9	27.6	26.3	28.4	25.5	21.0
Length of maxillary tooth row	62.0	59.6	55.4	55.2	52.8	50.5
Length upper carnassial	22.4	23.4	22.3	21.1	20.0	20.5
Width upper carnassial	11.8	11.8	11.1	10.2	9.8	9.8
Length lower carnassial	16.2	17.5	16.9	15.6	14.5	15.0
Diameter upper canine	14.7	14.5	12.3	10.7	10.8	10.3

* Measurements of *azteca* and *mayensis* after Young and Goldman (1946).

None of the adult females, all of which were collected in June or December, was pregnant, but one that was taken June 27 was lactating. Two juveniles were taken in late June. Adults weigh about 2.5 kilograms.

Specimens examined, 8, as follows: 2.5 mi. S Almolonga, 5600 ft., 2; 1 mi. SW Colotlipa, 2700 ft., 1; 6 mi. W Colotlipa, 2700 ft., 1; 1 mi. W Quechultenango, 3000 ft., 1; 5 mi. E Omiltemi, 6800 ft., 3 (skulls only).

Sylvilagus cunicularus cunicularius (Waterhouse).—This large cottontail is characteristic of the interior upland valleys of both the Tropical Deciduous and Pine-Oak zones of Guerrero. Unlike *Lepus callotis*, it was abundant and easily taken at the three stations where the two occurred together. This species has a wide altitudinal and ecologic tolerance. Although we took it only in rather arid situations between altitudes of 2700 feet and 5600 feet, it has been taken at Omiltemi at an elevation well over 7000 feet (E. R. Hall, in conversation). It seems to prefer areas of grass and brush, most of which are associated with man and his activities; there is no indication that it ranges into heavily forested situations.

Intergradation with *S. c. pacificus*, which inhabits the coastal lowlands of Guerrero, might be anticipated, but our specimens from the Chilpancingo area seem to be more nearly typical of *S. c. cunicularius*. In breadth of rostrum (average 21.1 mm.) and depth of rostrum (average 17.4 mm.) they are similar to *cunicularius* (see Nelson, 1909: 239), and the ears are large (average 80 mm.).

Even though the testes of males taken in June were enlarged (23 mm. to 27 mm.), none of the females taken then was pregnant.

Specimens examined, 10, as follows: 2.5 mi. S Almolonga, 5600 ft., 6; 1 mi. SW Colotlipa, 2700 ft., 3; 1 mi. W Quechultenango, 3000 ft., 1. Additional record: Chilpancingo, 1 (Nelson, 1909).

Sylvilagus cunicularius pacificus (Nelson).—The range of this large cottontail in Guerrero is the narrow coastal area below an elevation of 1500 feet. Cottontails in the drier inland valleys, even though on the Pacific slope of the Sierra Madre del Sur, are referable to the subspecies *cunicularius*.

Specimens examined, 2, as follows: El Triente, 30 km. N Acapulco, 1000 ft., 1; 53 km. S Tierra Colorada, 500 ft., 1. Additional records (Nelson, 1909): Acapulco, El Limón, Papayo, Zihuatanejo.

Tamandua tetradactyla hesperia Davis.—Four-toed anteaters were first reported from the west coast of México by Davis (1955) when he described *hesperia* on the basis of three specimens from Guerrero. Since then three additional specimens, also from Guerrero, have been received. Re-examination of the five skulls now available indicates that *hesperia* is readily separable from the east coast *mexicanus* on the basis of (1) short nasals, (2) short, narrow rostrum, (3) short dentary, and (4) depression of the frontal region. Other "characters" listed by Davis (*op. cit.*) are variable and thus not reliable diagnostic features. Cranial measurements of these five specimens are given in Table 8.

All of our specimens were taken by local hunters in the Tropical Deciduous Forest association. The specific site of capture is known for only two specimens. One was taken in an oak forest; the other, on a hill planted to corn. Month of capture of the five specimens: February, April, May, August, and December. None of the four females was gravid.

Specimens examined, 6, as follows: *Ca.* Acahuizotla, 2800 ft., 4; *Ca.* Chapolapa, 1000 ft., 2 (one skin only).

TABLE 8.—*Cranial measurements of Tamandua from central Guerrero*

	5322 ♀ (Type)	5610 ♀	5647 ♂	5646 ♂	5659 ♀ yg.
Greatest length of skull	117.0	120.2	125.7	—	106.1
Length of nasals	38.5	43.1	43.6	43.0	37.0
Width of rostrum	17.0	20.0	18.6	18.8	19.2
Width of cranium	41.8	40.3	40.1	—	38.3
Interorbital width	24.0	25.0	24.6	24.8	24.0
Length of rostrum (from lacrimal foramen)	52.4	56.5	58.8	54.7	47.2
Length of mandible	98.0	101.2	100.6	99.9	98.5

Dasypus novemcinctus davisi Russell.—On the basis of our specimens from Guerrero, the first to be reported from Southwestern México, the validity of *D. n. davisi* seems assured. Although external measurements of these specimens more nearly approximate those of *D. n. mexicanus*, cranial measurements agree well with those given by Russell (1953) for *davisi*. Comparison of the skulls of armadillos from central Guerrero with that of the type of *davisi* from Morelos shows the expected similarity. However, the size of the rostrum is variable in our specimens, as is the size of the maxillary teeth. Two of our adults have an extra upper molar.

Judging from the degree of closure of the basioccipital-basisphenoid suture, two of our three specimens (two males and one female) are adults. The female, taken June 23 in a highway culvert in the pine-oak woods, was lactating. Three very young individuals, apparently a family group, were taken on successive days from June 18 to 20 near Acahuizotla. Though uncommon in the Chilpancingo area, armadillos are probably more wide-ranging in Guerrero than present records indicate.

Measurements (two males followed by one female in parentheses): Total length, 770, 758 (785); length of tail, 375, 355 (450); length of hind foot, 85, 75 (65); height of ear, 40, 31 (35); weight, 3026, 2875 (——); length of skull, 89.2, 87.8 (93.2); palatal length, 57.7, 57.9 (60.6); zygomatic breadth, 37.3, 38.0 (41.1); interorbital width, 21.7, 21.2 (22.8); length of maxillary tooth row, 24.1 (extra molar), 21.3 (24.0, extra molar) mm.

Specimens examined, 6, as follows: Acahuizotla, 2800 ft., 5; Agua del Obispo, 3300 ft., 1.

Pecari tajacu humeralis (Merriam).—Merriam's (1901) description of *humeralis* is brief and gives few distinctive characters. We have available eight specimens from Guerrero that

range in age from old adults with worn teeth to a young animal about six months old. We have compared these with five specimens of *angulatus* from Texas with the following results:

(1) The snout of adult *humeralis* is abruptly narrowed at the juncture with the zygomatic arch so that the sides are nearly parallel; in *angulatus* the snout gradually tapers from the zygomatic arch forward. Measured at the "vertical" canal, the width of the snout of adult *humeralis* is 35.1–44.7 mm.; in *angulatus*, 45.6–55.9.

(2) The molars of *humeralis* are normally smaller and the molariform tooth row shorter than in *angulatus*. In five adult and subadult *humeralis* the upper molariform series ranges from 57.5 to 63.3 mm.; in one large female (No. 3503) it measures 66.8; in three adult *angulatus*, 65.0 to 66.8. Tooth size is best illustrated by M_3, the crown length of which in *humeralis* is from 15.5 to 17.3 mm. and in *angulatus* from 17.6 to 18.6 mm. It is evident from Merriam's measurement of 67 mm. for the upper molariform series that the type of *humeralis* is an unusually large animal similar in size to our No. 3503. In our oldest female from Guerrero, judged by degree of wear on the teeth, the length of the molariform series is only 62.3 mm. For further measurements see Table 9.

(3) Differences in the nasals described by Merriam (*op. cit.*) do not hold in our two young specimens—one each of *humeralis* and *angulatus*. In both, the nasals are long and slender and only slightly broader between the maxillae than between the premaxillae. In both they are strongly convex posteriorly. These two specimens are not of comparable age so we can make no statement regarding the comparative extensions of the premaxillae other than that they appear to be about the same.

(4) Merriam's description of color differences agrees well in so far as our specimens are concerned.

In summary, and based on our material only, *humeralis* is characterized by (1) snout tending to be parallel sided, (2) small molars and short molariform series, and (3) shoulder stripes

TABLE 9.—*Data on eight peccaries from Guerrero*

NO.	5331	5332	5403	5404	5321	3503	5333	5334
Sex	♂	♂	♂	♂	♂	♀	♀	♀
Age	Old	Yg. Ad.	Ad.	Sad	Sad	Ad.	Old	Juv.
Date	12/22	12/22	2/9	6/22	Apr.	8/5	12/22	12/22
Total length	915	780	850	—	920	992	915	730
Hind foot	205	210	200	—	190	214	205	180
Ear	97	97	—	—	—	93	95	80
Basal length	200	205	198	193	—	200	202	148
Zygomatic breadth	116.9	105.2	105.4	—	102.0	—	101.7	77.0
Interorbital width	54.8	56.4	54.4	53.5	49.0	53.7	55.9	42.3
Width of rostrum*	42.0	44.7	40.0	35.1	42.2	44.6	40.4	29.0
Palatal length†	128.8	126.4	125.4	121.3	—	125.3	132.4	87.5
Length molariform series	57.5	63.3	60.0	60.0	—	66.8	62.3	
Crown length M^3	11.9	13.4	12.5	12.3	12.0	14.1	12.4	
Crown width M^3	12.0	11.8	11.8	12.1	10.7	13.4	12.1	
Crown length M_3	15.5	16.2	14.8	15.5	16.7	17.3	17.1	

* Measured at "vertical" rostral canal.

† Measured from incisive foramen to interpterygoid notch.

External measurements of Nos. 5403 and 5321 taken from tanned hide; others from animal in the flesh by Davis.

No. 3503 from El Treinte; others from near Acahuizotla.

suffused with yellow. In *angulatus* the snout is tapered from the zygoma anteriorly, the molars are relatively larger, the molariform tooth row longer, and the shoulder stripes whitish.

Collared peccaries range from sea level to at least 7500 feet at Omiltemi and are fairly common wherever there is suitable habitat in central Guerrero. They seem to prefer the mesic and more heavily forested situations, usually in canyons, and, according to the inhabitants of Mexcala, they occur in the forested draws and mountainsides near the Río Balsas in the Balsas Basin. Leopold and Hernandez (1945) report the peccary as widespread in Guerrero. These animals are persistently hunted for food and the Mexican women cook them with avocado leaves in such a manner that the flesh is exceedingly palatable.

Our biological data are meager. A pregnant female was taken August 6 near El Treinte, 30 km. north of Acapulco; a juvenile female with only the first molars erupted was collected December 22 near Acahuizotla. An old male (No. 5331) weighed entire 26.5 kilos; an old female (No. 5333), 23 kilos.

Specimens examined, 13, as follows: Mts. near Acahuizotla, 3500 ft., 3; 5 km. W Acahuizotla, 4500 ft., 4; El Treinte, 30 km. N Acapulco, 1; Papayo, 200 ft., 5 (BSC).

Odocoileus acapulcensis (Caton).—Lydekker's (1915) treatment of the Acapulco deer and its Central American relatives as subspecies of *Odocoileus virginiana* is, in our opinion, questionable for the following reasons:

1. The metatarsal gland is absent in all adults of *acapulcensis* we have examined, but a mere indication, in the form of a clump of white hairs, is present in young animals in their first and occasionally their second year.

2. The antlers of adult bucks of *acapulcensis* we have seen have no more than two tines in addition to the brow tine on each side, rather than three normally found in *virginiana.* Often the antlers in mature bucks consist of a brow tine and a single upward projecting spike or simply a spike without the brow tine.

3. In the flesh, *acapulcensis* seems to be shorter-bodied and shorter-legged for its weight than *virginiana.*

Several cranial differences are readily apparent when one compares skulls of comparable age of *acapulcensis* and *virginiana* (from Texas). Among them are (1) noticeably larger orbit, which suggests a relatively larger eye in *acapulcensis,* (2) nasals shorter and broader, both associated with the actually and relatively much shorter rostrum of *acapulcensis,* (3) skull proportionately broader relative to its length in *acapulcensis,* (4) auditory bullae about two-thirds as large in *acapulcensis,* etc.

Several of the described forms of white-tailed deer from southern México southward agree with *acapulcensis* in at least the first two features mentioned above. A skin only of *O. toltecus* we have from Oaxaca, for example, is bright chestnut in color, lacks metatarsal glands and is readily separable from any *virginiana* in our collection. We anticipate that when adequate material is available for study, the small deer of Central America will be found to constitute an allopatric species distinct from *virginiana* and comprised of several geographic races including, among other, *acapulcensis* and *toltecus.*

Aside from Caton's (1881) description of *acapulcensis,* which we quote in full, we have found no adequate account of this deer. "Smallest of all the North American deer. Head broad and full. Eye prominent and bright. Ear small and thin, covered with very short, fine hair, black outside and white inside. Nostrils large. Nose naked and moist. Neck slim, tapering, and elevated. Body short, round, and compact. Legs short and slim. Accessory hoofs small. Tail short, bushy, and rather flat. Antlers small and short, and flattened towards upper part, and notched at end, with small basal snags; beams are triangular near base. Pedicels high and far apart. Metatarsal gland wanting. Tarsal gland present. Face black. Under the head and throat white, but proportionally less than on common deer. Neck, back, and sides, dark chestnut brown; darkest on top of neck and back. Brisket nearly black. Belly, inguinal region up to the tail, and under side of that member, white."

TABLE 10.—*Data on nine specimens of Odocoileus acapulcensis from Guerrero*

No.	5651	5661	5335	5650	5405	5336	5569	5570	5406
Date	Jan.	Oct.	Nov.	Jan.	Feb.	Dec.	July	Dec.	Apr.
Sex	♂	♂	♂	♂	♂	♂	♂	♂	♀
Age	8–9 yrs.	4½ yrs.	4 yrs.	3½ yrs.	2½ yrs.	2½ yrs.	11 mo.	4 mo.	9 mo.
Total length	1510	1330	1435	1430	—	1280	1180	990	
Length of tail	160	200	200	150	—	150	130	130	
Length of hind foot	350	320	348	350	335	305	305	275	265
Ear from crown	95	—	110	100	90	95	100	70	80
Condylobasal length	205	218	206	200est.	199	188	182	150	159
Cranial width	64.6	67.5	71.4	67.8	62.4	62.9	60.1	54.0	57.0
Width at fronto-jugal suture	100.0	99.6	104.4	100.0	92.8	96.9	80.4	69.0	73.1
Least interorbital width	55.2	57.6	60.2	58.5	55.7	57.1	48.7	40.9	41.0
Length of nasals	68.7	61.1	69.4	64.0	64.8	61.2	57.3	45.8	49.8
Alveolar length maxillary tooth row	57.9	65.1	66.8	60.7	59.3	62.7	53.3	45.1	49.8
Length of mandible	172	175	175	175	170	165	160	133	136
Alveolar length mandibular tooth row*	65.3	72.9	74.3	68.5	66.2	68.7	64.9	43.8	50.4
Antlers:									
Points	1–1	2–2	2–2	2–2	1–1	1–1	nubs		
Brow tine	1–0	1–1	1–1	1–1	1–1	0–0			
Spread	127	202	200	210	152	107			
Diameter above burr	20.5	24.4	23.5	22.7	18.3	16.1			
Metatarsal gland	Abs.	Abs.	Abs.	Abs.	Abs.	Abs.	Pres.	Pres.	Pres.
Remarks (see corresponding number in footnotes)	1	2	2				3	4	3

All external measurements from tanned hide.
Age determinations after Severinghaus (1949).
* Exclusive of canines.
1. Teeth badly worn.
2. First molar and premolars worn.
3. Last molar not erupted.
4. Second molar not erupted. Spotted.

After comparing our specimens with Caton's description, we have little to add except to point out that an indication of the metatarsal gland is present in animals less than two years old, that the antler is not necessarily triangular in shape at the base (in some it is roughly ovoid in cross section), and that seasonal changes take place in coat color. His color description seems to be that for the winter coat, but we would emphasize the darkness (blackish gray with chestnut suffusion).

In summer, the upperparts, particularly the rump, are bright chestnut. Following are color notes on a male taken by Davis July 23. Upperparts: rump and lower back chestnut; shoulders and neck grayish; forehead and crown black; muzzle dark gray suffused with black; eye ring pale gray; outside of ears blackish, the inside clear white; top of tail chestnut. Underparts: midline of belly, inguinal and axillary areas, and insides of legs whitish; sides of belly and chest white suffused with chestnut; neck grayish white; throat and chin white, the black spot on each side of the lower jaw (which is present in winter) absent.

That this is a small deer is pointed up by data one of us (Davis) took on a buck judged to be about 2½ years old. Weight entire, 60 lbs.; weight hog-dressed, 45 lbs.; height at shoulder, 27 inches. Conventional external measurements: 1200-140-320-130 mm. External and cranial measurements and other pertinent data are presented in Table 10.

We have few data on the population dynamics of this deer. If our age calculations are reasonably accurate, the fawn (No. 5570) was born in August and conceived the previous January; the yearling (No. 5569) likewise was born in August and conceived in January; the young doe (No. 5406) was born in July and conceived the previous December. This, of course, assumes a gestation of seven months as in other *Odocoileus*. Near Omiltemi in late June a hunter came by our camp carrying the carcass of a fawn we judged to be two weeks old. These meager data indicate June through August is the fawning period with the rutting period from November through January. These data agree with the observations of Joaquin Villanueva who places the period of fawning as July and August. He also pointed out that bucks do not drop their antlers until April or early May.

This deer is fairly common in the Sierra Madre del Sur in Guerrero. Although we have definite altitudinal records only for elevations between 2800 and 7800 feet, deer likely occur throughout the wooded areas of the state. They are persistently, although not heavily, hunted throughout the year by local hunters and many of them are marketed in the smaller, isolated villages. Does and fawns are taken as readily as antlered bucks.

Specimens examined, 11, as follows: *Ca.* Acahuizotla, 2500–4000 ft., 7; La Mina, 6 km. E Acahuizotla, 3000 ft., 2; 2 mi. W. Omiltemi, 7900 ft., 1; 5 mi. E Omiltemi, 6800 ft., 1.

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NIMRAVIDES, A NEW GENUS OF FELIDAE FROM THE PLIOCENE OF CALIFORNIA, TEXAS AND OKLAHOMA

By David B. Kitts

The Arnett local fauna from Ellis County, Oklahoma (see Kitts, 1957) includes two remarkably well preserved and complete felid lower jaws. Investigation has revealed that these specimens are very similar to and probably conspecific with material from the Higgins local fauna which has been referred to *Machairodus* Kaup (see Hesse, 1940) and material from the Black Hawk Ranch local fauna which has been referred to *Pseudaelurus* Gervais (see Macdonald, 1948). A study of the Arnett, Black Hawk Ranch and Higgins specimens reveals that they are certainly not referable to *Machairodus* and that, although they bear a number of marked resemblances to the lower jaw of *Pseudaelurus*, their generic separation from this genus is almost certainly justified.

I should like to express my gratitude to Dr. Donald E. Savage of the University of California who allowed me complete access to the specimens in his charge and to Dr. J. R. Macdonald who permitted me to reproduce two figures from his paper on the Black Hawk Ranch carnivores. The plate was prepared by Mr. Irwin Gold. This study was supported by a grant from the faculty research fund of the University of Oklahoma.

The following abbreviations are used: O.U.S.M.—J. Willis Stovall Museum of Science and History, University of Oklahoma; U.C.M.P.—Museum of Paleontology, University of California. All measurements are in millimeters.

Family FELIDAE Gray, 1821
Subfamily Nimravinae Trouessart, 1885
Nimravides gen. nov.
(Figs. 1, 2; Plate I)

Type.—*Nimravides thinobates* (Macdonald) 1942.

Distribution.—Black Hawk Ranch local fauna, California (Clarendonian age). Higgins local fauna (late Clarendonian or early Hemphillian age). Arnett local fauna (late Clarendonian or early Hemphillian age).

Diagnosis.—Very large nimravine without anterolateral mandibular flange but with ventral symphysial extension which projects below ventral border of ramus. Vestigial P_2 sometimes present. Metaconid on M_1 vestigial. Carnassial notch on P^4 and M_1 relatively shallow. Parastyle relatively large.

One of the Arnett specimens consists of a perfectly preserved lower jaw (O.U.S.M. No. 36-4-S13) with a complete and virtually unworn dentition. I have chosen to describe this specimen in detail and to refer to the description in the course of the discussion of the less complete specimens.

The transition from the anterior to the inferior border of the mandible is rather abrupt along the lateral margin, somewhat more abrupt for example than in any of the larger recent felids which I have examined. There is no lateral flange. An impression of sharp angulation of the jaw is imparted by a median

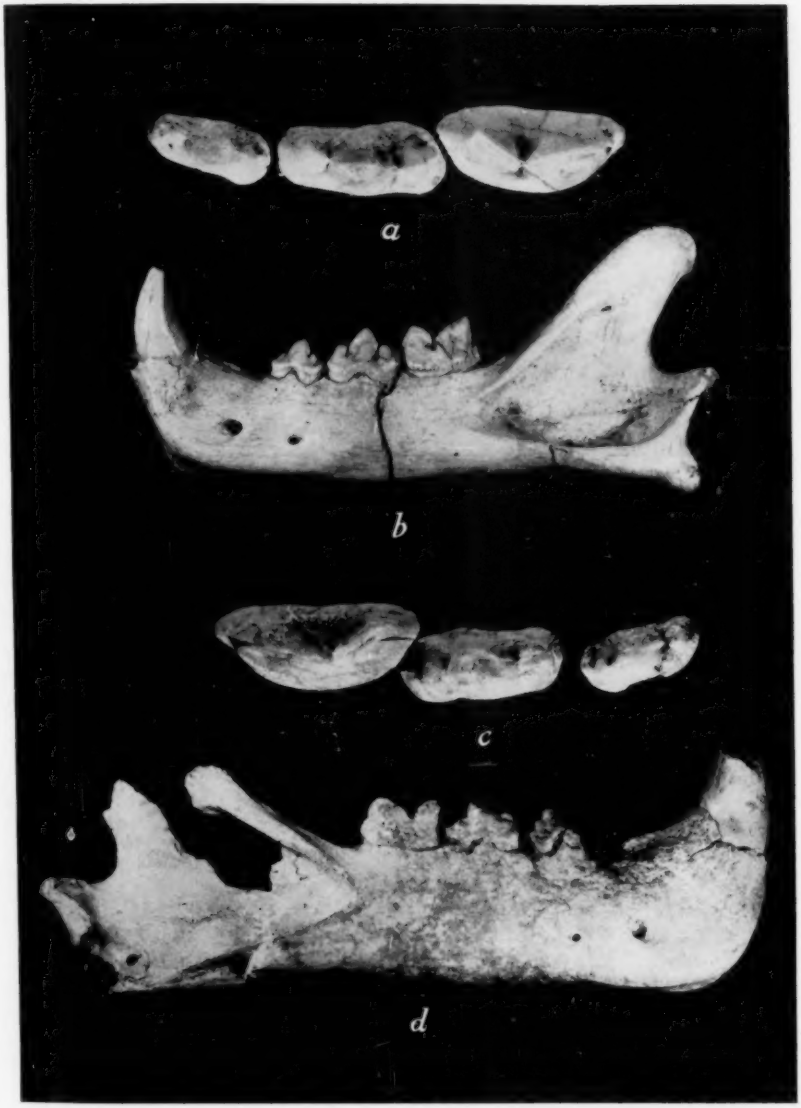

PLATE I

Nimravides thinobates (Macdonald). *a* and *b*, O.U.S.M. No. 36-4-S13, left lower jaw; *a*, crown view of cheek teeth, ×1; *b*, lateral view, ×½; *c* and *d*, O.U.S.M. No. 36-4-S15, right lower jaw; *c*, crown view of cheek teeth, ×1; *d*, lateral view, ×½.

flange formed of a ventral extension of bone adjacent to the symphysial line. The lateral surface of this flange is formed by a ventral extension of the symphysial surface. A median flange of this sort is a very common feature of the jaws of machairodonts but in these forms it is usually hidden in lateral aspect by the larger lateral flange. A structure very similar to this median flange is present in some large felines. Among the felines, however, it shows extreme intraspecific variation, being appreciably developed in only a few individuals of a particular species. The anterior portion of the lower jaw in *Nimravus bumpensis* illustrated in Scott and Jepsen (1936) and in some other species of *Nimravus* Cope, is strikingly similar to that of *Nimravides*.

There are two mental foramina, a larger one beneath the diastema and somewhat below the mid-height of the ramus at that point, and a smaller one beneath P_3 and at a somewhat lower level. The remainder of the jaw is very similar to that of a recent large felid. Compared to the jaw of an adult lion the coronoid process is relatively and absolutely broader and the angular process is deflected more sharply ventrally. A rather striking difference between the jaw of *Nimravides* and that of a lion is that the masseteric fossa is deeper with more sharply angular borders and the floor of the fossa is broader than in the latter genus.

The central cusp of P_3 is markedly laterally compressed. In lateral aspect this cusp is relatively broad and the crest is rounded. Running around the base of the crown is a distinct cingulum which rises sharply at the posterior end of the tooth to form a small posterior cingular accessory cusp. The anterior accessory cusp is bluntly pointed. The cusp is located well back from the anterior end of the tooth and is separated from the central cusp by a shallow vertical groove. The posterior accessory cusp is slightly higher and broader than the anterior accessory cusp. It is separated from the central cusp and the posterior

FIG. 1.—*Nimravides thinobates* (Macdonald). Type, U.C.M.P. No. 34513, right lower jaw fragment with P_3 and M_1; *a*, crown view; *b*, lateral view; ×½. (*After Macdonald*).

cingular cusp by vertical grooves. The tooth broadens somewhat posteriorly and gives the impression of being pitched slightly backward.

The central cusp of P_4 is similar to that of P_3. On P_4 the cingulum is not so pronounced as on P_3 and the posterior cingular accessory cusp consists of a barely discernible bump. The anterior accessory cusp is relatively longer and higher than in P_3, and is separated from the central cusp by a deep vertical groove which extends nearly to the base of the cusp. The posterior accessory cusp is slightly smaller than the anterior accessory cusp in P_4. The tooth is broader posteriorly than anteriorly and differs from P_3 in not being pitched backward.

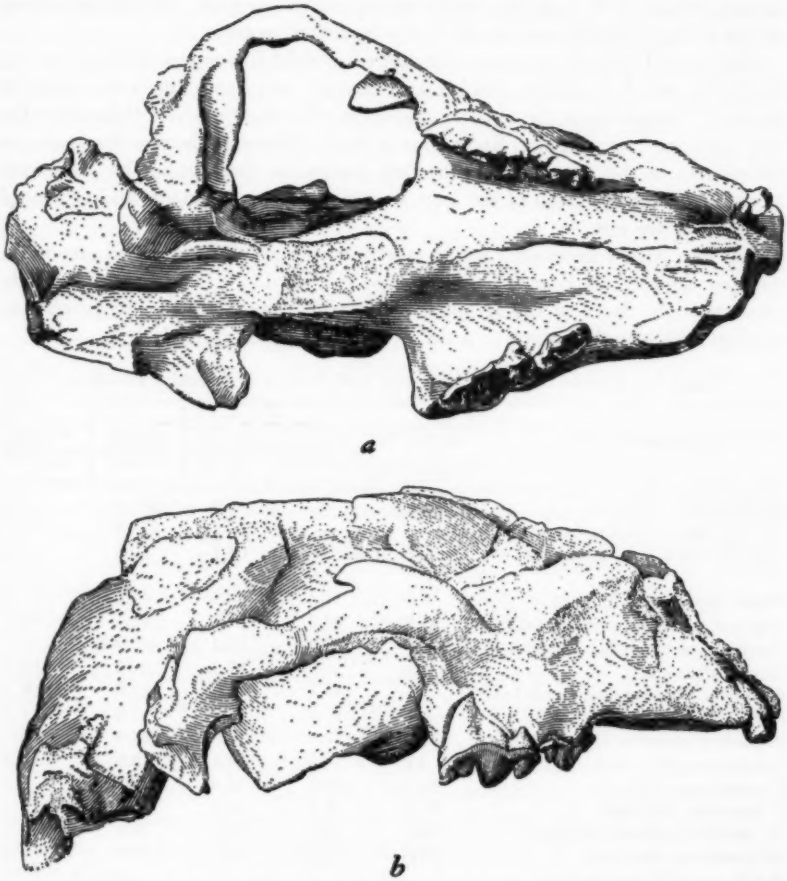

FIG. 2.—*Nimravides thinobates* (Macdonald). U.C.M.P. No. 34512, skull; *a*, palatal view. *b*, lateral view. ×½. (*After Macdonald*).

In lateral aspect the anterior border of the paraconid of M_1 is straight and inclined backward at an angle of about 20° from the vertical (the vertical refers to a line perpendicular to the long axis of the ramus). The dorsal border of the paraconid blade is slightly convex anteriorly. Posteriorly it curves sharply into the vertical carnassial notch. The protoconid shearing blade is about one and a half times as long as that of the paraconid. It appears to be pitched back because the posterior border is nearly vertical and the anterodorsal edge, although slightly convex, ascends from the carnassial notch at an angle of about 40° from the vertical. There is a very small but distinct metaconid. With the exception of a small concavity just anterior to the metaconid, the lateral surface of M_1 forms an evenly curved convex surface. The lateral surface of the tooth is deeply excavated by the carnassial notch.

The second Arnett specimen consists of a right lower jaw (O.U.S.M. No. 36-4-S15) which is longer, thicker and deeper, and has a diastema which is relatively longer than the smaller specimen described above. Otherwise the two jaws are very similar. Except for a slight difference in size there are no differences in the dentitions of the two specimens that cannot be attributed to the fact that the teeth of the larger specimen are well worn while those of the smaller are not.

The two Arnett specimens differ markedly in size. Because they are otherwise so similar and because the teeth of the smaller specimen are virtually unworn while those of the larger one are well worn, it seems reasonable to attribute the size difference to a difference in age and possibly sex.

TABLE 1.—*Measurements of lower jaws and teeth of Nimravides thinobates*

MEASUREMENTS, mm.	U.C.M.P. NO. 34513, TYPE, BLACK HAWK	U.C.M.P. NO. 34514, PARATYPE, BLACK HAWK	O.U.S.M. 36-4-S13 ARNETT	O.U.S.M. 36-4-S15 ARNETT	U.C.M.P. NO. 30296 HIGGINS
Total length	—	—	182.0	221.0	
Anterior side canine to posterior side M_1	—	—	112.2	128.3	
Anterior side P_3 to posterior side M_1	69.5	(alveolus P_3) 78.0	67.7	70.5	
Depth symphysis	—	—	148.8	64.4	
Depth of ramus between P_3 and P_4	41.8	42.9	34.5	42.4	
Thickness of ramus between P_3 and P_4	17.8	18.7	15.4	20.2	
Length diastema	—	—	27.6	38.6	40.6
C anterior-posterior diameter at base	—	—	18.0	23.0	25.6
C transverse diameter at base	—	—	11.8	13.9	14.1
P_3 anterior-posterior diameter	18.5	—	17.5	18.0	
P_3 transverse diameter	8.7	—	8.4	8.6	
P_4 anterior-posterior	24.4	24.7	24.2	23.3	
P_4 transverse diameter	11.2	11.8	10.6	10.5	
M_1 anterior-posterior diameter	28.2	31.1	27.4	30.0	
M_1 transverse diameter	12.5	13.5	12.6	12.8	
Height coronoid process from inferior border of ramus	—	—	83.9		
Transverse length condyle	—	—	42.2		

There are several large, fragmentary felid limb bones in the Arnett collection which are apparently referable to *Nimravides*. They are, on the whole, feline in character.

The two specimens from the Arnett local fauna are so precisely similar to the type (U.C.M.P. No. 34513) and paratype (U.C.M.P. No. 34514) specimens of *Pseudaelurus thinobates* from the Black Hawk Ranch local fauna which have been described by Macdonald (1948) that they may be considered conspecific. The type specimen consists of a right mandibular fragment with P_3, P_4 and M_1. The anterior portion of the ramus is missing but there is some indication of the symphysial flange. The posterior end of the jaw from just posterior of M_1 is lacking, but enough remains to show that the masseteric fossa was deep and sharp-bordered. The paratype is also a right mandibular fragment with P_4 and M_1 and the broken roots of P_3. Enough of the anterior portion of the jaw remains to show distinctly a portion of the symphysial flange. Part of the coronoid process is preserved as is most of the deep, sharp-bordered masseteric fossa. The dentitions of these two specimens are the near structural duplicates of the dentitions of the two Arnett specimens.

In addition to the type and paratype specimens Macdonald assigned to *Pseudaelurus thinobates* a distorted skull with right I^3, P^3 and P^4, and left P^3 and P^4 (U.C.M.P. No. 34512). On the basis of the size of the specimen and the structure of the teeth it is reasonable to associate the skull with the two lower jaw specimens.

Measurements of the teeth of the skull of *Nimravides thinobates* from the Black Hawk Ranch local fauna (U.C.M.P. No. 34517) are as follows: P^3 anterior-posterior diameter, 20.2; P^3 transverse diameter, 10.0; P^4 anterior-posterior diameter, 33.3; P^4 transverse diameter at protocone, 15.4; P^4 transverse diameter at paracone, 10.2 mm.

The metacone of M^1 is relatively long and bladelike and is separated from the paracone by a rather shallow, broad carnassial notch. The parastyle is relatively much larger than in any specimens of *Panthera* or *Felis* which I have examined. There is a very small preparastyle. P^3 has a large central cusp and in addition to anterior and posterior accessory cusps, a well-developed posterior cingular cusp.

Macdonald, in his original description of *Pseudaelurus thinobates*, stated, "*Pseudaelurus thinobates* probably developed from a west coast form of *P. intrepidus*, as a terminal species of this phylum in the area." This statement represents a reasonable interpretation of the ancestry of these Black Hawk Ranch felids and I believe that, on the basis of the material available to him, Macdonald was justified in separating them from species of *Pseudaelurus* at the specific level only. A re-examination of the taxonomic status of his *Pseudaelurus thinobates* is possible on the basis of the Arnett specimens apparently referable to this species.

The structure of the lower jaw in *Pseudaelurus* and *Nimravides* differs only in the greater angulation of the chin and the presence of a symphysial flange in

the latter genus and the absence of these characters in the former genus. The lower teeth of the two genera are quite distinct. The anterior and posterior accessory cusps on the lower premolars are higher relative to the central cusp in *Nimravides* than in *Pseudaelurus*. In *Nimravides* the metaconid on P_4 is relatively smaller, and the canine is more laterally compressed than in *Pseudaelurus*.

A comparison of the dentition of the Black Hawk Ranch skull referred by Macdonald to *Pseudaelurus thinobates* with an upper dentition of *Pseudaelurus intrepidus* Leidy from the Esmeralda formation described by Stock (1934) reveals striking differences. In *Pseudaelurus* the carnassial notch of P^4 is relatively deeper and narrower than in the Black Hawk ranch specimen and the parastyle is much less strongly developed. A further difference is the presence of a large anterior accessory cusp in P^3 of the Black Hawk Ranch specimen and its absence in *Pseudaelurus*.

Burt, in his paper on the Hemphill machaerodonts (1931), described a specimen from the Higgins local fauna (U.C.M.P. No. 30296). This specimen consists of the mandible anterior of P_3. The roots of the canine, parts of the alveoli of P_3, I_2 and I, and the alveolus of a vestigial P_2 are preserved. Burt stated, "this specimen differs from the other specimens at hand in the following respects: canine relatively and actually much larger and incisors much smaller; presence of vestigial P_2; no outer flange projecting below lower border of ramus; angulation of jaw less marked."

Burt referred this specimen to *Machairodus* sp. indet., but was apparently uncertain of even its proper generic position. Burt's uncertainty is fully understandable in view of his very limited material and the lack, at that time, of descriptions of other, similar material. Hesse (1940) in the course of his general description of the Higgins fauna referred the specimen mentioned by Burt and another specimen with the same portion of the jaw preserved and of identical structure (U.C.M.P. No. 30625) except for the lack of the alveolus of P_2, to *Machairodus catocopis* Cope. The two Higgins specimens are so similar to the Arnett specimens that it is probable they belong to closely related if not identical species.

A comparison of the Black Hawk Ranch and Arnett specimens with specimens of *Machairodus catocopis* from the Hemphill fauna reveals many striking distinctions. There is in *Machairodus* a small but distinct lateral flange which is of course absent in *Nimravides*. The masseteric fossa in *Machairodus* is not so deep nor so sharply bordered as in *Nimravides* but the floor of the fossa is about as broad. The coronoid process of *Machairodus* is relatively much lower than in *Nimravides* and is not so sharply recurved.

P_2 and P_3 differ markedly in the two forms. In *Machairodus* the accessory cusps are relatively higher on the lower premolars, particularly in P_3, having almost a columnar aspect in lateral view. In *Nimravides*, on the other hand, the central cusps are relatively low. P_4 in the two forms is generally quite similar although the carnassial notch of *Nimravides* is deeper.

The Black Hawk Ranch and Arnett specimens are, almost beyond question, conspecific. The Higgins material may represent a distinct species but on the basis of the available material it is impossible to be certain.

Relationships.—In the morphology of the lower jaw, particularly in the high recurved coronoid process, *Nimravides* is very like *Felis* and *Panthera*, and nearly indistinguishable from *Pseudaelurus*. The only mandibular character in which *Nimravides* differs from these genera is in the structure of the "chin." Although the anterior end of the jaw may bear a superficial resemblance to some machaerodonts, it is closest to the condition found in *Nimravus*. The structure of the lower jaw indicates clearly that *Nimravides* is a nimravine.

In all known parts *Nimravides* is closer to *Pseudaelurus* than to any known form. I believe, however, that generic separation of the two forms is desirable largely on the basis of differences in the form of the "chin," the prominence of the accessory cusps on P_3 and P_4, the character of the carnassial notch in P^4 and M_1, the size of the metaconid in M_1, the parastyle development in P^4 and in size.

Although the differences between *Pseudaelurus* and *Nimravides* are numerous and marked, they do not seem to me to be too numerous or marked to have arisen between sometime late in Miocene time and early in Pliocene time. It is entirely possible, however, that *Pseudaelurus* and *Nimravides* were separately derived from some earlier, more primitive nimravine, possibly *Nimravus*.

It is more reasonable to assume, it seems to me, that the symphysial flange of *Nimravides* which is so similar to that of *Nimravus*, represents an ancestral character retained, rather than a character lost and then regained in a line of descent including *Pseudaelurus*. There are no dental characters in *Nimravides* that could not be theoretically as readily derived from *Nimravus* as from *Pseudaelurus*.

Whatever its ancestry, *Nimravides* is, to a limited degree, convergent to the machairodonts, or at least to *Machairodus*. In all of the characters which distinguish *Nimravides* from *Pseudaelurus*, *Nimravides* is the more like *Machairodus*.

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School of Geology, Univ. of Oklahoma, Norman. *Received June 25, 1957.*

FOOD HABITS AND BEHAVIOR OF THE GRAY SQUIRREL

By John T. Nichols

The suburban village of Garden City, New York, is overrun with gray squirrels, *Sciurus carolinensis*. Their numbers and their boldness, contrasted with respectful behavior at our summer place in the country further east on Long Island, where they are hunted to some extent, are a nuisance and seriously interfere with my bird-banding operations. Broken bread or crackers attract them particularly. They will often steal bread from my bird trap instead of picking up pieces lying nearby. If the door of the trap drops on them, they do not mind, and usually back out without difficulty. They have also acquired great skill in taking food from the trap without tripping it, thereby not being temporarily barred from taking more. When one occasionally gets caught and is treated somewhat roughly to discourage its return, I suspect that it is back before long. Sometimes when one sees me coming to chase it, it ducks into the trap when almost within arm's reach, runs off with a piece of bread, dropping the door behind it, and is back almost as soon as I have reset the trap and turned away.

Since publishing something on their food habits (Jour. Mamm., 8: 55–57, 1927) I have made various supplementary notes on the Garden City gray squirrels. The following are compiled from my more recent journals.

The maples' buds in spring, and later seeds, make an important contribution to their diet. On May 11, 1948, a squirrel was well up in the slender sunlit outer twigs of a white maple, busily picking and nibbling the full-grown keys which hung profusely in bunches, usually reaching down to get them. Numerous keys which had been dropped were on the ground below, the majority complete except for the inner seed pod which had been removed.

Their budding in spring is not confined to maples and elms. On April 3, 1936, one or two squirrels were biting off pussy-willow catkins, nibbling them held between the forepaws; on April 19, one in our horse chestnut tree was biting off the swollen sticky buds and eating them in the same manner. On May 2, 1944, one was among the outer twigs of our big buttonwood tree, picking and eating the opening buds for a few minutes. In one case at least it was the little green button that it took.

On a dull morning in late January, 1929, with the ground more or less sleet-covered, a squirrel was climbing about in a sycamore maple tree by the railroad station, feeding on the seeds. It picked an old dry raceme, removed such seeds as were still clinging to it, and dropped it. On December 27 of the same year, a cloudy morning with the ground covered by one or two inches of crusted snow, there were two squirrels in a sycamore maple at the same place, picking and eating seeds from the keys. The keys of this maple remain in the trees in winter. Squirrels are more often seen feeding on those of the Norway maple, which fall early, picking them up from the ground where they lie about conspicuously.

The morning of October 4, 1929, was bright and cool, and at about 8:30 AM a squirrel was picking up fallen Norway maple keys. Sometimes it ate the kernel

and sometimes buried the key, in a couple of the latter cases so shallowly that the wing was in view, and I readily picked it up thereby. I handed the squirrel one I had pulled up, which this time it ate.

These squirrels are very happy-go-lucky about burying things, to them just a pleasant form of mental and physical activity, no doubt. On September 20, 1956, in the late afternoon there was a smallish gray squirrel in front of the house. It was picking up, nibbling and running about on the grass with pieces of cracker put out for birds, occasionally digging into the sod and burying one.

The first mention I find of their eating seeds from fallen pods of the honey locust, which sometimes strew the ground, is on December 8, 1940. One on the ground back of the house was holding and nibbling such a pod.

On January 10, 1943, I saw a small gray squirrel on the ground start to climb to the feed table which stands against the buttonwood tree. A second, larger squirrel approached leisurely down the tree and, whereas it made no threatening move that I could see, the first descended and moved off on the ground while the second occupied the top of the table. The smaller squirrel presently picked up a honey-locust pod, seemed to bite a seed out of it, dropped the pod to eat the seed, and picked the pod up again; this was repeated several times. Retrieving the pod when the squirrel had left confirmed the observation. Half or more of one edge of the pod was chewed and the seeds (with one exception) were gone; the edge and seeds of the remainder were intact.

On December 4, 1954, a squirrel picked up and nibbled at a small pod, which it dropped at my approach. The shell of the pod was broken on one side where a couple of seeds were missing. There were many pods on the ground, and later it was easy to find others that had been stripped in this way. In one there were 9 breaks through the shell where a seed had been removed, but 11 or 12 seeds where the shell of the pod had not been tampered with, all on one side. In only one case where a single seed was missing was there also a small break on the opposite side of the pod through which it possibly might have been taken. Considering the stem end the head of the pod, and the surface at the greater angle with the stem the upper one, the breaks through the shell were on the left side. They also were nearly all on the left side of two other long pods picked up, which had been more completely stripped.

At one time the gray squirrels seem to concentrate on one food, at another time on a different one. Comparative availability is probably a factor; it is possible that at one time, or in one year, the same crop of buds, seeds or nuts is sweeter than in the next. They doubtless like variety, as well as having their preferences. There are probably few edibles they do not turn to on occasion. There is a tall, branching ash shoot in front of the house that has grown up from the stump of a fallen tree. Of recent years its upper twigs have been laden with keys, as they are this February (1957). On the morning of October 26, 1954, I saw a squirrel climb up among the keys, pick and nibble a couple. The ground beneath was strewn with keys, singly or in bunches, which might have fallen

naturally, and I found one wing from which the seed had been bitten. This is the only time I have seen a squirrel pay any attention to the fruit of the ash.

In season, one frequently sees squirrels eating the horse chestnuts which come from the large tree southeast of our house. For instance, on October 30, 1934, one was in the yard nibbling at a nut. I picked up another that had been scarred and noticed fragments of shell where one seemingly had been consumed; on September 12, 1936, numerous pieces of shell and several peeled and more or less nibbled horse chestnuts lay near the tree where squirrels had evidently been working on them. But I do not think they are particularly fond of this kind of nut.

One September the horse chestnuts in the tree were fully formed, but their shells still greenish, the peeled nuts white. I made a note that on September 16 gray squirrels were carrying them in their mouths, as they had been doing for a day or two previously. In a comparatively short period on September 18, I noticed a squirrel running off with such a nut six times, also one in the tree picking a nut; on September 19, five more were carried off or nibbled on the ground. On September 20 I twice noticed one running off with a nut, and later the ground beneath the tree was thickly spattered with shells and bits of shells, and a couple of white nuts essentially intact lay there. The squirrels presumably shelled the nuts when in the tree, but not always, as a few shells lay at a little distance from it. I could see no nuts remaining in the tree, and supposed their harvest to be essentially complete. They always carried them out of my range, not necessarily in the same direction; I do not know where, or what they did with them. There may have been something different about that year's crop of horse chestnuts, or a group of squirrels may just have taken a fancy to them.

It is sometimes said that gray squirrels bite into apples and pears to get the seeds, which they presumably eat, but they eat the meat also. On November 28, 1946, one was sitting in a low tree for several minutes, holding and nibbling at a small apple, presumably eating the meat, although flecks of it were dropping. When the squirrel had gone I found what seemed to be the same apple on the ground below, with much of the end opposite the stem nibbled away. The core and seeds had not been exposed. Most of the latter were no good, as the apple's center was bad, but one at least seemed sound. Nearby lay a sizeable piece of another apple, with a seed missing from its exposed groove. On November 26, 1954, a squirrel on the piazza rail was holding a small apple (or possibly pear) which was about one-third eaten, nibbling at the periphery of the side and evidently relishing the meat, as none was dropped.

Gray squirrels sometimes enjoy rolling on loose earth. In the late afternoon of August 2, 1942, after a warm day, one crossed the grass in front of the house, paused at a flower bed, dug into the earth under the slanting edge of a big tridacna shell and then sprawled and rolled to one side and the other on the strip of earth between shell and grass for a couple of minutes. The earth was rather moist from recent rains and the squirrel left a squarish area, about 30 centimeters on a side, smoothed by this procedure. On April 23, 1953, a mild,

moist, cloudy morning, I saw one dig up the bare ground by some trees and bushes, exposing a patch of loose dark earth (about 14 × 9 in.), and roll on it for a minute or so with seeming enjoyment. I could not make out if it rolled all the way over. On the cloudy morning of July 21, 1954, the ground very dry, one was "bouncing and rolling" playfully on loose earth surrounding the base of a little lilac in the grass for a minute or two.

In the morning of December 13, 1942, it snowed an inch or so; that afternoon the snowfall practically ceased and it became colder with a westerly wind. I cleared the top of a small table 28 inches high which stood against the leeward side of the trunk of a buttonwood tree and placed some broken dry bread thereon. A squirrel approached over the snow from windward. It passed close to the table without pausing and went by for some yards. Presently it came back from leeward, searching the snow, and once digging down through it not far from the table. About six feet from and more or less to leeward of the table there was a bench, some 17 inches high, to which it finally climbed, and down again. It could not have seen the top of the table from the bench, but very likely got better wind of it, for it now climbed one of the leward table legs to its top, where it sat eating piece after piece of the bread. I assume that the squirrel had a keen nose for bread, whereby it detected its presence when on the snow near and to leeward of the table, but that it was unable to locate it as it could when a foot or two off the ground.

On December 1, 1930, there was a gray squirrel in a small maple tree by the barn, working on twigs from which considerable bark had been stripped; with a mouthful (probably of this bark) it ran from there to enter the cupola on top of the barn, which is much frequented by squirrels. We may assume that from such sheltered winter nests come the more or less independent young squirrels one sees in May. They are active, self-confident and pretty well able to take care of themselves, but must lack the strength and judgment of their elders; there are instances to show that the latter still feel responsible for them.

On the fair, warm afternoon of May 16, 1931, with a brisk breeze, there was a squirrel running along the rail behind the top of a fence, carrying some large object. On stopping to investigate I found it to be a young squirrel, about two-thirds grown, which its mother was holding by the breast or shoulder and more or less curled around her head. She jumped off the fence with it to the base of a nearby tree, behind which she left it, and went up the tree trunk, where she flattened, head down, watching me. The young one remained clinging upright to the base of the tree but made no attempt to climb; it dodged a little to one side and the other to avoid my gaze, as I looked around the tree from either side.

Our kitchen, on the ground floor, faces east. From a south window of my second-story room I look down on a narrow ledge over the kitchen windows. There is a small porch south of the kitchen, and I also look across to a corner of its roof, which slopes abruptly upward to the north. Of a gray afternoon toward sunset on May 7, 1956, from this window there was seen a fuzzy half-grown gray squirrel running back and forth on the ledge immediately below

me. It seemed that the only way it could have gotten onto the ledge was to jump down from the corner of the south porch roof, which was about 2½ feet higher than the nearest point on the ledge and little more than 4 feet from it in horizontal distance. The upward slant of the roof and slight downward slant of the ledge would probably have made it impossible for even a grown squirrel to jump back.

An old squirrel was at the edge of the porch roof for a time, perhaps considering jumping onto the ledge, but went away without doing so. The young one finally attempted to scramble down over the edge of the ledge; this was sufficiently overhanging that it fell to the ground, a drop of 12 or 13 feet. While I was wondering if it were seriously hurt, it got up and ran under the south porch. Presently an old squirrel, followed by the young one, appeared from there, crossed to a large honey locust which stands east of the house, went up its trunk (which the young also climbed without difficulty) and well into the branches, where the young one stopped. The old squirrel went on further, then came back, picked up the young one and carried it up and out onto more tenuous branches that went over the house, disappearing from my view where they did so. I could not see how it was held except that the young made a large furry mass around the old one's neck. It must have been relatively smaller than it first seemed.

On May 19, 1943, a gray squirrel was carrying large green horse-chestnut leaves to add to a nest of dead leaves in a crotch of an adjacent honey locust. Its route lay back and forth along a bare locust branch, and once when its burden was too large to be manageable, it left some of it part way, then returned and brought this remainder. Casual observation showed that it continued the trips for half an hour, though latterly perhaps somewhat tired, and making them less rapidly. Sometimes it brought a spray with two or more leaves attached, once only a small twig without any leaf. In all it was seen to make upwards of twenty trips.

American Museum of Natural History, New York. Received March 2, 1957.

RATE OF INCISOR GROWTH IN THE MOUNTAIN POCKET GOPHER

By Richard S. Miller

Since pocket gophers use their incisor teeth to excavate rather extensive burrow systems in hard soil, their rate of incisor growth and attrition is unusually high (Howard and Smith, 1952). The purpose of this study was to compare the rates of incisor growth of pocket gophers from different habitats, and to determine the extent to which extrusive incisor growth is a subspecific adaptation to local habitat conditions.

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during the preparation of the manuscript, and to Dr. Elmer Remmenga for advice on statistical procedures.

Methods and materials.—The pocket gophers used in this study were collected from two ecologically different localities, each within the range of a different subspecies of *Thomomys talpoides.* One of the localities, Black Mesa, is located on the western slope of the Rockies about 27 miles west of Gunnison in Gunnison County, Colorado. The elevation of this locality is approximately 10,000 feet, the growing season is short and, although there is a fairly heavy winter snowfall, the total annual precipitation is low. The Black Mesa sample was taken from mountain meadows in which the vegetation is predominantly grasses and mixed forbs and the soil is relatively coarse and shallow.

The other locality is at Livermore, Colorado, on the eastern slope of the Rocky Mountains, about 20 miles north of Fort Collins in Larimer County, at an elevation of approximately 6,200 feet. The gophers from Livermore were trapped in irrigated alfalfa fields where the soil is a deep sandy loam.

Although the gophers from Black Mesa differ from topotypes of *Thomomys talpoides fossor* Allen, they are at present assigned to this subspecies; those from Livermore belong to the subspecies *retrorsus* Hall. Pocket gophers from deep soils and low elevations tend to be larger on the average than those from shallow soils and high elevations, and those living on light-colored soils tend to have a lighter-colored pelage than those living on dark-colored soils (cf. Davis, 1938; Durrant, 1952; Ingles, 1950; Kennerly, 1954). Morphological differences between gophers from Black Mesa and Livermore are consistent with these described trends in variation; the Black Mesa populations live at a higher altitude, and on relatively shallow, dark-colored soils, and are smaller and have darker-colored pelages than those from Livermore.

The animals were housed in laboratory cages and fed a balanced diet of commercial range chow. Measurements of incisor growth were made at intervals of 6 to 8 days, at which time the body weight of each animal was recorded and its teeth were marked according to the method described by Howard and Smith (1952). A dental drill with a 7/8-inch carborundum disk was used to mark a transverse notch close to the gingival margin of one upper and one lower incisor. At each subsequent observation, an additional mark was made and the distance between marks was measured to the nearest 0.1 mm. with a venier caliper.

Results.—Table 1 shows the mean body weights and rates of extrusive growth of the upper and lower incisors of each individual. Measurements were taken for periods of 25 to 41 days for each individual, although the growth rates were remarkably constant and shorter periods of observation would undoubtedly suffice.

Pocket gophers from Black Mesa (1–8) showed an average growth rate of 0.54 ± 0.017 mm. per day for each upper incisor and 0.92 ± 0.127 mm. per day for each lower incisor, while those from Livermore (9–14) showed corresponding rates of 0.58 ± 0.024 mm. and 1.08 ± 0.045 mm. per day. The highest indi-

TABLE 1.—*Body weights and rates of extrusive incisor growth of pocket gophers from Black Mesa and Livermore*

INDIVIDUAL	BODY WEIGHT, *gm.*			EACH UPPER INCISOR			EACH LOWER INCISOR		
	Mean	S.D.	Range	Days	Total growth	*mm*/day	Days	Total growth	*mm*/day
Black Mesa:									
1	65.0	2.34	(62– 68)	41	21.4	0.52	25	18.2	0.72
2	73.0	1.66	(70– 75)	41	22.6	0.55	41	34.9	0.85
3	84.2	2.90	(80– 88)	36	17.5	0.48	36	30.6	0.85
4	89.6	2.88	(86– 93)	25	12.5	0.50	25	22.3	0.89
5	90.0	4.18	(85– 96)	41	21.8	0.53	41	43.9	1.07
6	96.0	2.34	(92– 98)	25	13.3	0.53	25	23.7	0.95
7	97.0	2.24	(94–100)	25	13.5	0.54	25	23.3	0.93
8	104.4	3.78	(100–108)	25	16.2	0.64	25	28.0	1.12
Livermore:									
9	83.7	3.36	(79– 88)	33	17.6	0.53	33	31.7	0.96
10	95.0	2.87	(92–100)	41	21.8	0.53	41	39.5	0.96
11	106.3	2.83	(102–110)	41	22.0	0.54	41	45.5	1.11
12	113.1	3.60	(108–118)	41	25.4	0.62	37	40.0	1.08
13	113.2	2.17	(110–116)	36	21.2	0.59	41	50.3	1.22
14	121.8	2.66	(118–126)	41	28.0	0.68	41	46.6	1.14
Mean	95.2					0.56			0.99
S.D.	5.42					0.056			0.113

vidual rate recorded was 1.22 mm. per day, or 17.1 inches per year, for each lower incisor of a gopher (No. 13) from the Livermore sample.

The average differences in growth rate between the two populations were significant at the 0.1 level for upper incisors and at the 0.001 level for lower incisors, but the average weight difference between animals from the two populations was also significant at the 0.001 level. Inspection of the data in Table 1 shows that there is a tendency for larger animals to have a greater rate of extrusive growth, particularly of the lower incisors.

When the data for the Black Mesa and Livermore samples are combined and tested for regression, the mean rate of extrusive growth of each upper incisor becomes 0.56 ± 0.015 mm. per day with a regression value (b) of 0.00256 mm. per day with each 1.0 gram increase in body weight. This correlation is significant at the 0.01 level. The mean rate of extrusive growth of each lower incisor becomes 0.99 ± 0.030 mm. per day with a highly significant regression of 0.0080 mm. per day with each 1.0 gram increase in body weight. These relationships are illustrated in Fig. 1 with the regression lines fitted to the mean values for body weight and incisor growth. When regression values were calculated for the upper and lower incisor growth rates of each sample, the difference between samples was not significant.

These data show, therefore, that the correlation between body weight and the growth rate of the lower incisors is highly significant and, although the average rates for the two populations are significantly different, the individual

rates for animals from both populations lie along the same regression line. The correlation between body weight and growth rate of the upper incisors is significant only at the 10 per cent level, but the rates for individuals from both populations also lie along the same regression line. It should also be noted that the slope of the regression of lower incisor growth on body weight is much greater than that for upper incisor growth on body weight, and that the ratio between upper and lower incisor growth rates is, therefore, not the same for each individual.

Discussion.—Previous studies have demonstrated two sources of variation in the rate of extrusive growth of the incisors of rodents and rabbits. Shadle (1936) found that female domestic rabbits (*Oryctolagus cuniculus*) have a greater rate of incisor growth and attrition than do males, and that the rate for pregnant females is also greater than that for non-pregnant females. Since the sample for each sex was relatively small and none of the animals was in breeding condition, this relationship could not be tested. Dalldorf and Zall (1930), Downs (1931) and others have shown that incisor growth is also a function of nutrition. Downs (1931) recorded differences associated with a variety of diets for rats (*Rattus norvegicus*) and Dalldorf and Zall (1930) were, in fact, able to cause a cessation of incisor growth in guinea pigs (*Cavia cobaya*)

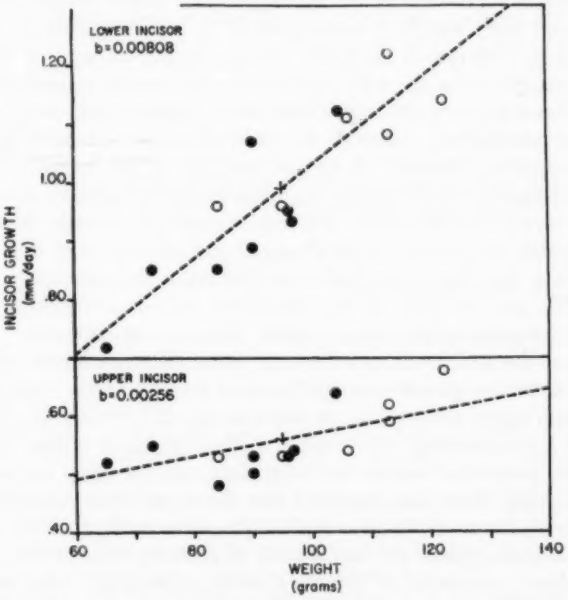

FIG. 1.—Regression of upper and lower incisor growth on body size. Rates for individuals from Black Mesa sample are shown by dots, those from Livermore by open circles. Dotted lines are fitted regressions.

by deprivation of vitamin C. Since the pocket gophers in this study were fed a balanced diet, and since the diet of each individual was the same, we may assume that nutrition was not a factor in the observed variation in growth rates and that the growth rates that were recorded were probably near the maximum rates possible for each individual. This does not mean, however, that these rates were necessarily "normal" in that they were identical to those that would be expressed in a natural environment.

Howard and Smith (1952) have pointed out that pocket gophers probably make greater damands on their incisors than do other species of rodents or rabbits and that they, therfore, have a far greater rate of extrusive growth and attrition. Although the results of the present study include a greater range of variation and although the maximum observed rate of 1.22 mm. per day, or 17.1 inches per year, is the highest rate that has been reported, the average rates observed during this study are comparable to those reported by Howard and Smith (1952). They measured the growth of the incisors of two individuals of the species *Thomomys bottae* and reported average values of 0.62 mm. per day for each upper incisor and 0.99 mm. per day for each lower incisor; the highest rates that have been reported for other species are 0.29 and 0.34 mm. per day for the upper and lower incisors of domestic rabbits (Shadle, 1936).

The different regression values for upper and lower incisor growth show that increased body weight is accompanied by a correspondingly greater increase in the growth rate of the lower incisors than of the uppers. No explanation has been given for the differential rate of extrusive growth between the upper and lower incisors, although Howard and Smith (1952) have enumerated some of the possibilities. Although the individual rates observed in this study were quite constant, the rate of attrition and, hence, the length of the incisors varied considerably, and there was no correlation between body size and incisor length or between incisor length and rate of extrusive growth. Measurements of incisor width, as an index of the diameter and robustness of the incisor, did, however, show that there is a significant correlation between body weight and incisor width, and between incisor width and rate of extrusive growth. The correlation between upper incisor width and rate of extrusive growth was significant at the 0.02 level and the correlation between lower incisor width and rate of extrusive growth was significant at the 0.01 level. Furthermore, the width of each upper incisor was, on the average, 15 per cent greater than the width of its corresponding lower incisor, so that the upper incisor has a greater diameter and presents a broader cutting surface than the lower incisor. Howard and Smith (1952) have also suggested that the upper incisors might be harder than the lowers, but no evidence is available to prove or disprove this hypothesis. There are, however, three obvious sources of abrasive wear in the activities of pocket gophers: excavated of burrow systems; cutting the roots and stems of food plants; and griding the lower incisors against the edge and back of the uppers, presumably to sharpen them. Laboratory observations suggest that the last of these three activities is just as important as the others, if not more so.

Since the upper incisors have a slightly greater cutting surface and are considerably stouter than the lowers, and since the upper jaw remains stationary while the lower incisors do most of the cutting, the activities of burrowing, feeding and sharpening the teeth produce greater abrasion of the lower incisors and a differential growth rate is, therefore, necessary.

If the values reported in this study are an approximate indication of incisor growth rates in nature, one must conclude that there is, at present, no evidence to show that the trends shown in these data represent a direct adaptation to local habitat conditions. Smaller gophers occur in coarser, more compact soils where the abrasive effect of burrowing activities would presumably be relatively high, and yet they have the lowest rates of incisor growth. Extrusive incisor growth in rodents and rabbits is undoubtedly an adaptation to incisor use and abrasion, and it is probably safe to assume that the rate of extrusive growth is adapted to the habits and needs of a particular species, but this rate is apparently so high in the pocket gopher that a wide range of individual variation can be expressed without seriously affecting the value of the adaptation.

SUMMARY

The rates of extrusive incisor growth were studied in pocket gophers from two different habitats. Although the average rates for the two populations were significantly different, there is a direct correlation betwen body weight and rate of incisor growth and the rates for individuals from both populations were found to follow the same regressions. The differential rate between upper and lower incisor growth is also correlated with body weight, so that changes in rate of growth are more pronounced in the lower than in the upper incisors.

Although extrusive incisor growth is an adaptation to incisor use and attrition, and although the rate of growth is probably adapted to general species requirements, it does not appear to be a direct adaptation to local habitat conditions. In view of the fact that small gophers, which occur in coarser and more compact soils, have a lower rate of extrusive growth than large gophers, it would seem that the rate of extrusive growth is so high in pocket gophers that a wide range of individual variation can be expressed without seriously affecting the value of this adaptation.

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OBSERVATIONS ON THE BURROWING RODENT *SPALAX* IN IRAQ

By Charles A. Reed

In many parts of Eurasia and extending into northeastern Africa, *Spalax* (the single living genus of the muroid family Spalacidae) is the commonest burrowing rodent. Unlike most fossorial mammals, its feet are not the primary dirt-dislodging tools; instead, *Spalax* uses the incisor teeth almost entirely for loosening soil.

In correlation with this use of the teeth in burrowing, the jaw articulation has become particularly specialized, the typical antero-posterior sliding arrangement of the rodent condyle in the glenoid fossa being greatly accentuated. The lower jaw can be pulled further posteriorly than in other rodents; a special flange of the squamous portion of the temporal has been evolved to check this backward movement and the external auditory meatus has become displaced somewhat posteriorly, also. Vinogradov (1927) has discussed this masticatory situation in *Spalax* in somewhat greater detail, but I find his description of the presence of a secondary, or false, mandibular fossa, indented in part into the typmanic bulla, to be misleading. I also find his drawing to be misleading in the implication that something new is formed. Actually, the whole arrangement seems merely to be a further specialization of the already specialized rodent jaw mechanism; whether the bursa in *Spalax* does or does not involve any surface of the tympanic bulla can only be determined by dissection.

The whole masticatory apparatus is obviously highly effective and very strong. Niethammer and Kammerlöwe (1934) released a captive *Spalax* in a room, only to have it immediately begin tearing the plaster off the wall. They spoke, too, of the rapid disappearance of their specimen into dry stony ground. In contrast with the obvious specialization of the jaws, the feet are small and relatively delicate (Plate I); the claws are merely blunt round nubbins.

I had some opportunity to observe these interesting animals while a member of the 1954–55 Iraq-Jarmo Archeological Expedition of the Oriental Institute, University of Chicago.[1] No detailed study could be attempted, however, because of the press of more immediate duties connected with the excavations. But in this part of the world *Spalax* obtrudes itself upon the archeologist's consciousness, for the rodent is usually a prior excavator in the archeologist's site and has often been mixing things up for thousands of years, to the exasperation of man, who thus finds small cultural artifacts displaced vertically (not always downward) and out of stratigraphic sequence. In addition, this same type of displacement of materials is always a potential source of error in collecting charcoal to be used for radiocarbon (C^{14}) dating.

The surface mounds of *Spalax* could easily be mistaken for those of American pocket gophers, and have sometimes been mistaken for the mounds of true

[1] My work in southwestern Asia, as a member of this expedition, was financed by a National Science Foundation grant to the Department of Anthropology, University of Chicago.

moles. Like moles, spalacids are not inhibited by human proximity, as they may choose the center of one's tent floor as a mound site. In the more humid climate of central Europe, *Spalax leucodon* does not make surface mounds, but packs the excavated earth into the tunnel walls with powerful thrusts of its broad, padded, horny nose (Montagu, 1924). *Spalax leucodon*, as observed by me in Iraq, has the same specialized nose and presumably uses it in the same way, but obviously cannot dispose of all the earth in this way in the harder soils of the drier Iraqi environment, and so must bring the excess to the surface. Considering the blunt head and the broad tough nose (and thinking, too, of the unspecialized feet) it seems possible that the dirt in the burrow may be pushed by the head.

The mounds are a common feature of the Iraqi grassy plains and foothills, between the lowland desert to the south and west, and the Zagros Mountains that rise to the north and east. But the same mounds, indicating the active animals, are also found high in the mountains; I have seen them thickly clustered in small clearings in virgin deciduous forest at altitudes of 5000–5500 feet, in the northern corner of Iraq within a few miles of the Iranian and Turkish borders. The annual rainfall here, as calculated from the limited data in de Vaumas (1955) is certainly in excess of 40 inches and probably approaches 50; the snowfall alone, I was told, will reach 10 feet each winter. I do not remember seeing any mounds above tree-line, which in those regions is at approximately 5500 feet. The lower limit of their distribution has seemingly not been recorded, although the mounds have been noted near Mosul (Cheeseman, 1920) at an altitude of approximately 750 feet, where the annual rainfall is 17 inches or less and the summers extremely hot and dry.

PLATE I

Spalax leucodon from Jarmo, east-central Iraq; left, ventral view; right, dorsal view of same animal. Photographs by Frederick R. Matson.

The following more detailed observations were made at the archeological site of prehistoric Jarmo, in the Chemchemal Valley of eastern Kirkuk Liwa approximately midway between Kirkuk and Sulimaniyah, the two largest cities in east-central Iraq. The altitude is 2500 feet, the annual rainfall about 20 inches (limited to the winter and spring), and the temperature varies from slightly subfreezing with occasional light snows in winter to consistent readings over 100°F. for most daylight hours in summer. The original vegetation was probably that of a scattered oak or mixed-deciduous forest, but now man and his domestic animals, seeking firewood and forage, have stripped off everything but the annual grasses and the hardiest of ground-hugging shrubs. Much of the soil is gone, too, yet *Spalax* not only persists but thrives. The species here is *S. leucodon* (Hatt, in press).

At Jarmo, burrows in use were found to a depth of 75 cm., as found in archeological test pits; the same species in Hungary is said to burrow to a depth of 4 feet, whereas *S. ehrenbergi* in Palestine (Portal, *in* Pocock, 1917) is reported as burrowing to 3 feet. Probably the type, depth and hardness of the soil are controlling factors in depth of burrowing. It was our observation that where the vertical wall of an archeological test pit intersected a burrow, the opening was plugged with loose dirt, and then that exposed burrow end was used for pushing out excess dirt (much to the annoyance of the archeologist in the pit). The animals were never seen to expose themselves in pushing out such excess dirt, either at the surface or at an exposed burrow end.

Members of the genus do emerge, however. Portal (*in* Pocock, 1917) noted them feeding away from their burrow entrances at night and the Kurdish natives of the Jarmo area were well aware that the "blind rat" comes out at night but sometimes gets lost (they say) and cannot find its way back to its burrow. As nocturnal surface wanderers, *Spalax* must furnish food to carnivores and, as would be expected, their remains may be found in owl pellets (Bate, 1945). I did not myself observe any spalacids above ground, but one such individual was brought alive into camp at dawn the morning of May 11, 1955, and something of its digging technique was observed.

Not knowing at the time that *Spalax* burrows best in hard ground, I tried it in a pile of loose damp earth. The animal obviously had only one instinctive action when placed on the ground under such circumstances; it showed absolutely no exploratory tendencies but began burrowing immediately. To my amazement this particular individual (completely unharmed and extremely active) took 2 minutes and 20 seconds to get underground; in similar circumstances a mole such as *Scapanus* would, I am certain, have vanished from view in 15 seconds or less. The soft dirt seemed to baffle the animal; it was tremendously active, biting furiously, heaving upward with the head, scrabbling with the paws, twisting the body through some 100° or more, but still took over 2 minutes to get itself covered.

The action of the feet was as follows: the two front feet moved together, very rapidly, in a series of convulsive scratching movements, following which

the hind feet, also moving together in a series of convulsive movements, kicked the loose dirt out of the way. Since this animal was out of its natural habitat, and in a frenzy besides, such behavior was certainly not typical of normal activity in the burrow. It was the relative ineffectiveness of its frantic actions and the relatively long time it took to get underground that were particularly noted at the time.

Close examination of the head shows that there is no external indication of an eye and the animals are obviously completely blind. In preparing a skin, a tiny black pinhead of an eye is found, however, adherent to the inner surface of the dermis, but no traces of ocular muscles or optic nerve could be seen.

Compared to what has been learned about many families of mammals, relatively little is known of the Spalacidae; not only are the behavior and anatomy relatively unstudied, but the geographical limits of the species have not been determined. Inded, even the number of species is in dispute. Ellerman and Morrison-Scott (1951) list three species (*microphthalmus, leucodon* and *ehrenbergi*) but think that *leucodon* may really be a subspecies of *microphthalmus*. Hatt (in press) doubts if two species actually are found in Iraq, since he reports S. *leucodon* from northern Iraq while Harrison (1956) identifies the spalacids from the same part of the country as S. *ehrenbergi*. Perhaps, thus, *ehrenbergi* and *leucodon* intergrade and are not separate species.

Spalax thus offers a fruitful subject of study to naturalists living in areas where the animals occur.

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HOME RANGES OF DEER MICE IN SOUTHERN ARKANSAS

By John P. Redman and John A. Sealander

Measurement of home range size has become a more or less routine part of many mammal population studies (Hayne, 1950); a great deal of effort has been expended (Calhoun, 1955; Davis, 1953; Hayne, 1949; Stickel, 1954) in determining the amount of variation in size of the calculated home range which may be attributed to factors which are inherent in the trapping methods (trap-revealed range) as compared to variations resulting from such variable factors in the environment as food, cover, topography, weather and fluctuations in population density *per se*. Nevertheless, some of the techniques of home range measurement have been widely enough adopted so that some reasonably valid comparisons of home range size can sometimes be made. With a continued accumulation of home range data in the literature it may become possible to determine, at least on a roughly quantitative basis, the influence of such factors as latitude with its related climate, seasonal availability of food and variation in cover types. In this connection, it may be noted that relatively few determinations of home range size have been reported from the southern United States, and consequently the information provided here may prove useful for comparison with more northern faunas.

The following study was made during 1955 and 1956, incident to other mammal population studies, in an area located approximately 10 miles north of Pine Bluff, Jefferson County, Arkansas, on the western side of the Arkansas river. The study area consisted of a 153-acre portion of immature oak-pine forest which was divided into one-acre plots. The principal dominants in the association were oaks (southern red oak, *Quercus falcata;* post oak, *Quercus stellata;* white oak, *Quercus alba*), which comprised about 57 per cent of the assemblage, and pines (loblolly pine, *Pinus taeda*; yellow pine, *pinus echinata*), which made up about 30 per cent of the total. Other tree species made up the remainder. Mast was abundant in the area at all seasons. One-acre square plots were trapped from March, 1955, until October 1955. From November, 1955, until February, 1956, the plot size was increased to four-acre squares.

Methods.—Large size ($3 \times 3 \times 10$ in.) Sherman sheet-metal single-catch traps were used. Peanut butter was used for bait. A fairly large quantity of bait was placed on the rear "bait hook" and a small attracting portion at the entrance of the trap. Traps were rebaited at the start of the second week of trapping, or more often if necessitated by ants or weather. The trapping periods ranged from 8 to 14 nights depending upon weather and other factors.

Grid sites were randomly selected in the 153-acre plot by drawing cards from a twice-shuffled deck of playing cards. Specific cards represented certain location points within the major area which were considered as the northeast coordinates for either the one- or four-acre grids. In the one-acre plots the traps were arranged in a grid so that the outside traps were on the perimeter. A total of 144 traps (12 parallel rows with 12 traps per row) were spaced at 19-foot

intervals in each one-acre plot. In order to prevent any unnecessary destruction of cover, the traps were so placed that when walking through the grid it was possible to check four rows of traps. Closer inspection was required, however, where the cover was dense. In the four-acre plots a total of 289 traps (17 parallel rows with 17 traps per row) spaced at 26-foot intervals was used.

Captured mice were ear-tagged with fingerling tags. No difficulty was experienced from loss of tags by marked animals. No animal was caught more than once in the same trap. After capture the trap was closed so that subsequent captures would extend the home range and reduce the amount of any distortion in calculated home range size caused by repeat captures in the same trap or by close spacing of traps (Hayne, 1950; Stickel, 1954). Closing of "catch" traps left fewer available traps in the animal's home range, and in that manner served somewhat the same purpose as increasing the trap spacing. Tanaka (1953) mentions that artificial nest boxes might well alter the natural behavior of the animal. Catch traps which are repeatedly reset and rebaited may to a large extent correspond to nest boxes, unless an ample supply of food, or food which is more attractive than the trap bait, is present in the animal's habitat. Closing of "catch" traps does, however, have the effect of not giving any indication of degree of utilization of different parts of the range, but no attention was directed toward this aspect of the home range in this study.

Home ranges were plotted on coordinate paper using the inclusive boundary strip method (Blair, 1942; Stickel, 1954) and the area (in square inches) was measured with a planimeter. This measurement was then translated into terms of acres of apparent home range.

Results and Discussion.—A total of 12 home range grids were established and trapped during a ten-month period. Nine of the grids were one-acre squares; three were four-acre squares.

Home ranges were not calculated for any animal with fewer than three captures. Also those animals with more than one-third of their captures on the perimeter were not considered for calculation of home ranges. Home ranges calculated for animals with a third or less of their captures on the perimeter were considered to more nearly approximate true home ranges than those with a high percentage of perimeter catches, as animals caught frequently on the perimeter would obviously indicate home ranges extending beyond the periphery of the study plot. Thus, of a total of 62 small mammals trapped in the grids during the course of the study, 40 were not considered suitable for calculation of home ranges. Apparent home ranges calculated for the remaining 22 deer mice, comprising three different species, are presented in Table 1.

The number of captures needed to give an approximation of true home range is subject to much disagreement, but many of those who favor a larger number of captures (Blair, 1942; Tanaka, 1953) have included repeat captures in the same traps and have trapped for longer periods. Much remains to be determined as to how often an individual animal may shift its home range. If home range shifts do occur periodically, then measurements based on trapping periods

TABLE 1.—*Apparent home ranges of three species of deer mice in oak-pine woodland*

SEX	NO. OF CAPTURES	HOME RANGE, acres	PLOT SIZE, acres	NIGHTS OF TRAPPING	TRAPPING PERIOD
Peromyscus maniculatus:					
♀	3	0.13	1	8	Mar. 28–Apr. 18, 1955
♂	5	0.07	1	11	July 18–Aug. 1, 1955
♂	7	0.20	1	11	July 18–Aug. 1, 1955
♂	4	0.04	1	11	Sept. 14–25, 1955
Peromyscus nuttalli:					
♂	4	0.14	4	14	Jan. 24–Feb. 7, 1956
♂	4	0.11	4	14	Jan. 24–Feb. 7, 1956
♀	5	0.13	4	14	Jan. 24–Feb. 7, 1956
♂	4	0.12	4	14	Jan. 24–Feb. 7, 1956
♀	3	0.13	4	14	Jan. 24–Feb. 7, 1956
Peromyscus leucopus:					
♂	3	0.07	1	11	Apr. 25–May 6, 1955
♀	8	0.40	1	10	Aug. 16–26, 1955
♂	5	0.19	1	10	Aug. 16–26, 1955
♂	3	0.10	1	10	Aug. 16–26, 1955
♀	3	0.09	1	10	Aug. 16–26, 1955
♂	4	0.12	1	10	Aug. 16–26, 1955
♂	3	0.16	1	9	Aug. 17–26, 1955
♀	7	0.21	4	13	Nov. 8–21, 1955
♂	3	0.08	4	13	Nov. 8–21, 1955
♂	4	0.14	4	8	Dec. 6–17, 1955
♂	3	0.46	4	14	Jan. 24–Feb. 7, 1956
♂	4	0.10	4	14	Jan. 24–Feb. 7, 1956
♂	3	0.11	4	14	Jan. 24–Feb. 7, 1956

separated by lengthy time intervals, may be of a summative character and not give a true indication of the amount of home range the animal may be using over shorter time intervals. Another factor to be considered is that the bait may be so attractive as to cause an animal to travel beyond its true or normal home range. If a "trap habit" is acquired, a permanent addition to the home range may be made as long as the area is under traps. In this study little difference was evident in apparent home range sizes of mice with three captures as compared with those with four or more. Use of the inclusive boundary strip method of computing apparent home range also compensated, in part, for the rather small number of trapping records.

For *Peromyscus leucopus* the average apparent home range size of females was slightly larger (0.18 acres) than of males (0.15) acres). Some difference was also apparent in the average home range size of individuals captured more than three times (0.19 acres) as compared with those captured three times only (0.15 acres), although the averages were probably distorted by the extreme values for each group. If the one extreme value (0.46 acres) is eliminated from the group of animals captured only three times, then the average apparent home range of the other animals in the group would be about half (0.10 acres) that

of those which were captured more than three times. This lends support to the observation of Burt (1940) that smaller home range figures do not represent actual small home ranges but result from insufficient trapping records. The average apparent home range of *P. leucopus* from the one-acre grids was 0.16 acre as compared with an average of 0.18 acre for those from the four-acre grids. The difference is not great but is in the direction that would be expected with increasing grid size (Mohr, 1947) and also increased spacing between traps (Hayne, 1950).

All but one of the five *Peromyscus nuttalli* were captured four or more times. The average apparent home range was 0.13 acres and there appeared to be no real difference in the ranges of males and females. The smaller home range of *P. nuttalli* as compared with *P. leucopus* might be due to the arboreal habits of *P. nuttalli*, and the home range would tend to have more of a three-dimensional aspect than in the other species of deer mice, with a resultant decrease in area traversed on the ground. The writers, however, do not attach nearly as much importance to the dimension of height in the over-all range of this species as was done by Goodpaster and Hoffmeister (1954), since it was never apparently as arboreal in its nesting, feeding and other behavior patterns in Arkansas as in Kentucky. This was probably to a large extent due to the more open stands of oak-pine, with little understory, in which this species is found in Arkansas, as compared to the dense, impenetrable and bushy habitats in which it occurs in Kentucky. *Peromyscus nuttalli* is evidently not limited in its choice of habitat to the type described by Goodpaster and Hoffmeister (*ibid.*) since it occurs in the same areas in which both *P. leucopus* and *P. maniculatus* are found in Arkansas. The difference in behavior might possibly be of a subspecific nature, however. Dunaway (1955) obtained an average home range of 0.26 acres for three *P. nuttalli* in Tennessee, using the method of Haugen (1942). He believes that his estimations of the home ranges were overestimations resulting from assumed extensions out of the area. Also, from the description of the habitat, it appears that the ranges did not involve too much of an arboreal dimension. The number of captures and stations on which the ranges were based (30–18; 15–13; 18–14) seem more than adequate.

Only four *Peromyscus maniculatus* were trapped three or more times. The apparent home ranges averaged 0.11 acres and ranged from 0.04 acres (four captures) to 0.20 acres (seven captures).

Both intra- and interspecific overlap in home ranges occurred. This overlap resulted, at least in part, from the use of the inclusive boundary strip method of charting home range. Use of other methods, such as the exclusive boundary strip method (Stickel, 1954), the minimum area method (Mohr, 1947), and linear methods (Davis *et al.*, 1948; Hawbecker, 1955; Young *et al.*, 1950) would result in decreased apparent home range area, and would also show a marked decrease in degree and incidence of overlap. There were altogether nine instances of apparent home range overlap between individual *P. leucopus*, four between individual *P. nuttalli*, one between individual *P. maniculatus*, three

between individual *P. leucopus* and *P. nuttalli*, and one between individual *P. leucopus* and *P. maniculatus*. None of the ranges of female *P. leucopus* overlapped. As pointed out by Burt (1943) the area of overlap of home ranges based on calculated areas may be somewhat exaggerated. It is possible that home ranges may be irregular in outline, as Burt (*ibid.*) suggests, and that less neutral range might result from a certain amount of interdigitation of respective home ranges. On the other hand, Stickel (1946) shows much more overlap in ranges of *Peromyscus leucopus* than was evident in this study, but no indication of a sexual difference in this respect is given.

Simultaneous population studies of other species of small mammals besides deer mice, carried out in almost identical habitat (unpublished data), gave fairly consistent estimates for deer mice of all species of 5–7 per acre. These population estimates were in accord with the home range determinations since the three species of deer mice which utilized the same habitat, in varying degrees, seemed to comprise from 80 to 90 per cent of the small mammal population. Other small mammals, such as shrews, flying squirrels and pine mice, perhaps had only a small amount of ecologic overlap of home ranges with the deer mice due to their different niche requirements.

Summary.—Measurements of apparent home ranges were made for three species of deer mice during a ten-month period in nine one-acre and three four-acre plots located in oak-pine forest about 10 miles north of Pine Bluff, Jefferson County, Arkansas.

The four-acre plots provided a more reliable estimate of apparent home range size than the one-acre plots, since they included a greater proportion of complete home ranges and many peripheral catches, with resulting speculation concerning range continuation beyond the periphery, were avoided. The most consistent estimates were made for *Peromyscus nuttalli* in which the apparent home range size averaged 0.13 acres with a range from 0.11 to 0.14 acres. For *Peromyscus leucopus* the apparent home range size showed some tendency to increase with an increased number of captures, but the largest home range (0.46 acres) was recorded for an individual having only three captures. Even though all "catch" traps were closed, thus preventing more than one catch per trap, it seems probable that the closer spacing of traps in the one-acre as compared with the four-acre plots may have contributed to smaller home range sizes, especially during periods of low population when traps possibly were competing for animals. For *Peromyscus maniculatus*, which had an average apparent home range of 0.11 acre, a similar tendency toward increase in size of home range with increasing numbers of captures was evident.

It seems likely to the writers that larger numbers of captures may have increased the absolute home range size, but, as pointed out by Manville (1949), a maximum possible rather than a home range size more nearly approaching the average might possibly result through extending the trapping periods, with the probable likelihood of an increased number of captures.

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OBSERVATIONS ON INFANT JERBOAS WITH SPECIAL REFERENCE TO THE DEVELOPMENT OF THE TYMPANIC BULLA

By David L. Harrison

The burrow of a jerboa, *Jaculus jaculus loftusi* Blanford, excavated near Samarra in Iraq on December 16, 1954, contained an adult female with four infants in the nest chamber. The four infants were just under 100 mm. in length and must have been recently born, the eyes as yet unopened and the skin partly naked. They were almost helpless, making feeble crawling movements only

and uttering plaintive squeaking cries. As the mother was almost moribund when received it was clearly impossible to rear these interesting infants and two of them were preserved for study. Certain features of these neonatal jerboas seem worthy of note. The hind feet are already disproportionately enlarged and there is no trace of the two lost digits on them. The tail is surprisingly short, not so long as the head and body, and it already bears a short white tuft terminally. The external ear is extremely small, not as yet giving any indication of the large adult pinna. The abdomen is quite hairless but the vibrissae are already well developed. On the crown of the head and on the back hair is beginning to grow and is dusky blackish in color with some white hairs intermingled. At the root of the tail, only whitish hairs are present. Blackish hair is found just below the heels. These features are illustrated in Fig. 1.

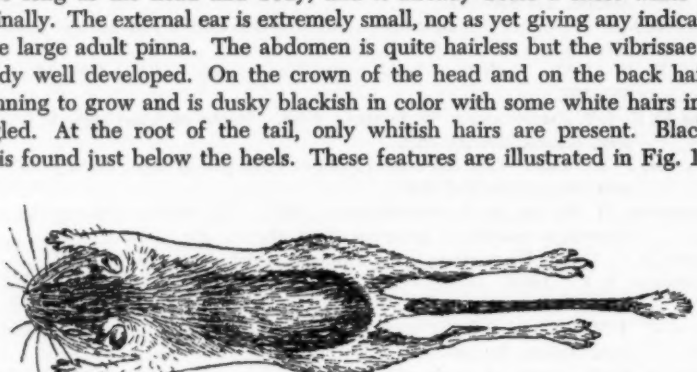

FIG. 1.—*Jaculus jaculus loftusi*, neonatal male No. 16.1677, collected December 16, 1954, near Samarra, Iraq. Natural size.

The skulls of these infants are also of great interest. Small and presumably deciduous incisors are present in the upper and lower jaws of both specimens but there is no trace of any deciduous cheek teeth. The general aspect of the skull foreshadows the peculiar form of the adult with one remarkable exception, namely, the tympanic region. The most striking feature of the adult *Jaculus* skull is the relatively huge tympanic bulla (Fig. 2). Ventrally the apices are almost or actually in contact, posteriorly the bullae project beyond the occipital bone, while superiorly they encroach considerably on to the vertical surface of the vault. Markings on the external aspect of the bulla demarcate five portions, marked in the figure: (A) An inferior lateral oval part including the bony auditory meatus and its lateral boundary which marks the attachment of the tympanic membrane; (B) an inferior part; (C) a postero-superior part; (D) an antero-superior part; and (E) a superior lateral sickle-shaped part. The condition in the infant jerboas is notable in that none of these inflated portions of the bulla are developed (see Fig. 3), although the manner of their formation can be conjectured. The tympanic bone is represented by a simple ring, incomplete in its supero-lateral part, enclosing the tympanic membrane which is thus fully exposed on the postero-inferior aspect of the braincase—a condition reminiscent of that found in some adult Insectivora, the Soricidae for example. The auditory ossicles are differentiated and the handle of the malleus can be seen through the membrane, as well as the periotic bone. Above the tympanic ring

and membrane there is a long process of the squamosal projecting backwards (the *processus supramastoideus* of Tullberg, 1899), which must become inflated to form the similarly situated superior lateral portion of the adult bulla (Fig. 2, E). Immediately above the squamosal process is an area of unossified membrane lying between the parietal bone antero-superiorly, the supraoccipital postero-superiorly, the mastoid postero-inferiorly and the squamosal antero-inferiorly . This membrane also extends deep to the squamosal process, which also lies superficial to the mastoid. This area of membrane clearly corresponds to the *fenestra postglenoidea* (*vide* Ognev, 1948; Vinogradov, 1930) of more primitive forms of the family Dipodidae, such as Allactaga (Fig. 2) in which this area remains as unossified membrane into adult life. In *Jaculus*, however, it becomes ossified and inflated as the antero-superior part of the bulla (Fig. 2, D). Vinogradov (1930), in his review of the classification of the Dipodidae, compared the structure of this part of the skull in the various genera. He pointed out that in the Allactaginae the mastoids are not inflated and form no additional chamber connecting with the middle ear, while in the Dipodinae they are inflated and do form such a connecting chamber. He also mentioned that in the Allactaginae the external wall of the mastoids is perforated by a fenestra. Vinogradov stated that in Dipus the postglenoid fenestrae open into the internal cavity of the braincase, while in Jaculus they are partly or entirely closed from inside by a portion of petromastoideum and are greatly enlarged, forming nearly equilateral triangles. In the infant Jaculus the mastoid is represented as a rather irregular-shaped bone with a central area yet unossified. It clearly ultimately forms the postero-superior part of the bulla (Fig. 2, C) but it is impossible to say from these specimens just how the ossification of the fenestra occurs at some later period after birth to form the fourth part of the bulla in the figure.

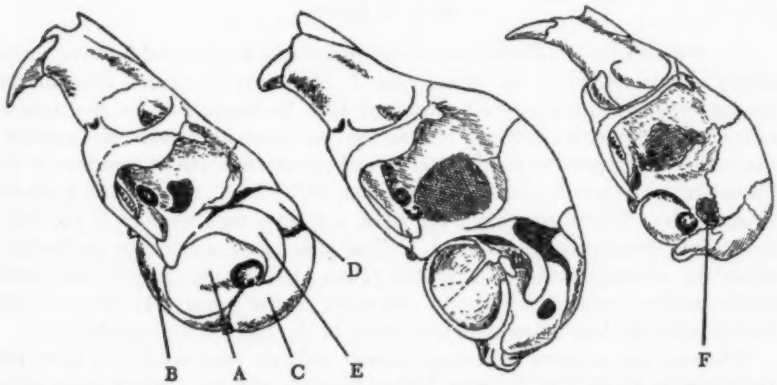

FIG. 2.—Lateral views of jerboa skulls. Left: *Jaculus jaculus loftusi*, adult female No. 9.1670, Haur al Hasa, Iraq; × 2; see text for description of portions of the tympanic bulla. Center: *Jaculus jaculus loftusi*, neonatal male No. 16.1677, near Samarra, Iraq; × 4. Right: *Allactaga euphratica*, adult male No. 1.1702, Ramadi, Iraq, May 1954; × 2; *F*, fenestra postglenoidea.

The remaining inferior lateral part (Fig. 2, A) and inferior part (Fig. 2, B) must both develop from the tympanic bone by expansion in both directions from the line of the tympanic membrane.

It is also of note that much of the membrane of the orbital cavity is still unossified in these two infants—a condition also found in primitive types of the family Dipodidae in adult life (e.g. *Allactaga, vide* Fig. 2) while in adult *Jaculus* only a small unossified area remains in this situation. The old axiom that "ontogeny repeats phylogeny" appears to be valid in the cranial development of *Jaculus* and it is remarkable that a great part of the development of the tympanic bulla occurs postnatally.

I am much indebted to my colleagues of the Medical Officers' Mess, R.A.F. Habbaniya, Iraq, for their assistance in obtaining specimens, especially Wg. Cdr. D.S. Grant, S. Ldr S. Seligman and F.Lt J. A. McGeoch and also to Messrs. A. Bickley, J. Davison and J. France of the Wadi Thar Thar Project for their help and hospitality.

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THE DISTRIBUTION OF MUSKOXEN IN CANADA

By J. S. Tener

The distribution and abundance of any mammal are governed by many interacting characteristics of the animal and its environment; certain fundamental requirements are necessary for sustained life. In Arctic regions the number of ecological niches is often very limited, and mammals are scarce. For example, the number of genera of resident terrestrial mammals north of tree line in the Canadian Arctic is only about 19 (Anderson, 1947) in an area of about a million square miles. Where conditions are right, a species may number in the thousands, but apparently the muskox, *Ovibos moschatus,* was never particularly abundant, although widely distributed (Hone, 1934). This may be attributed partly to the harsh Arctic climate, but more to the poverty of the available food supply, the low reproductive capacity of the species, and predation.

Whatever the reasons, historical records indicate that muskoxen were not abundant in Arctic Canada even before firearms and fur trading were introduced. Prior to 1862, when muskox hides were first sold at trading posts, travelers in the Arctic, such as Hearne (1795), Franklin (1823), and Back (1836) recorded seeing what they sometimes termed "numerous" muskoxen. However,

the daily records published in their books suggest that they never encountered herds numbering in the hundreds, or even many small groups daily, but rather only solitary bulls or a few small bands. MacFarlane (1905) confirmed this when he remarked that he observed very few muskoxen on any of his several specimen-collecting tours and his many summer and winter journeys within the Arctic Circle in the 1850's. It should be borne in mind, too, that observers traveling along river systems in summer may get an exaggerated impression of the number of muskoxen in the country, because at that season they usually frequent the river valleys to feed on the lush willow and other plant growth.

The taxonomy of muskoxen in the Canadian Arctic was last reviewed by Allen (1913). Present concepts of species and systematic procedures cast some doubt on the validity of Allen's interpretations. The present author is therefore undertaking a re-examination of the taxonomic relationship of Allen's three subspecies. For purposes of the present paper, however, they are considered good categories. They are *Ovibos moschatus moschatus,* the barren-ground muskox; *O. m. niphoecus,* the Hudson Bay muskox; and *O. m. wardi,* the Greenland muskox. The last-named subspecies was considered by Allen to occupy the Arctic islands and Greenland, but the ranges of the other two subspecies were left somewhat obscure. That of *O. m. moschatus* was said to be north of Great Bear Lake, extending eastward and intergrading in some unknown area with *O. m. niphoecus,* which was reported to inhabit the Thelon River country and the land north of Chesterfield Inlet to Boothia Peninsula.

FORMER DISTRIBUTION

The combined effect of fur trading and firearms drastically reduced muskox numbers and distribution. Hudson's Bay Company returns provide figures of the minimum kill from 1862, when hides were first traded, until 1916, one year before complete protection was given to the species. During that period, more than 15,000 skins were traded by the Company. It is known that many additional muskoxen were killed by whalers and explorers, and by natives for their own needs, both on the Arctic mainland and on the Arctic islands.

Hewitt (1921) published a few records of muskox skins traded by the Hudson's Bay Company; but as there are discrepancies between his figures and Company records recently furnished, the latter figures are given in the appendix. The Company's records were generously made available for publication by the Secretary of the Hudson's Bay Company, London, through the kindness of Mr. Charles Elton of the Bureau of Animal Population, Oxford University, where the records are located. Table 1 is a list of muskox skins received from the Athabasca, Mackenzie, Cumberland, Churchill, and York Factory Districts in the years 1862–1892 and 1896–1900. The administrative boundaries of the Company's fur trading districts underwent several changes throughout the muskox hunting period of 1862–1916. These changes have been recorded by Elton and Nicholson (1942) and the reader desiring details is referred to them, as the present author has used their revised districts. Table 2 records the number of skins sold in the revised districts in the years 1901–1916.

The records suggest that most of the skins traded came from three main regions on the Arctic mainland of Canada: from between Great Bear Lake and the Arctic coast at least 2,216 skins and from between Great Slave Lake and Bathurst Inlet at least 1,172 skins were bought in the period from 1862 to 1885. In those two regions, during the whole of the two periods covered by the records, a minimum of 8,564 skins were traded. In the region

TABLE 1.—*Hudson's Bay Company, muskox fur returns, 1862–1900*

YEAR	ATHABASCA DISTRICT	MACKENZIE DISTRICT	CUMBERLAND DISTRICT	CHURCHILL DISTRICT	YORK FACTORY DISTRICT	TOTALS
1862	—	20	—	—	—	20
63	—	14	—	—	—	14
64	—	14	—	—	—	14
65	—	25	—	66	—	91
66	—	—	—	1	—	1
67	—	—	—	10	4	14
68	—	9	—	68	—	77
69	—	18	—	4	—	22
1870	—	18	—	6	—	24
71	—	6	—	1	—	7
72	—	28	1	26	—	55
73	—	8	—	4	—	12
74	—	8	—	2	—	10
75	—	14	—	113	—	127
76	—	112	—	3	—	115
77	—	218	—	177	—	395
78	—	468	—	52	—	520
79	1	556	—	21	—	578
1880	37	501	—	13	—	551
81	7	356	—	14	—	377
82	—	239	—	75	—	314
83	2	233	—	31	—	266
84	2	239	17	138	—	396
85	14	308	—	63	—	385
86	1	318	—	—	—	319
87	5	246	24	—	161	436
88	163	1004	33	—	69	1269
89	234	934	55	—	147	1370
1890	423	762	50	—	446	1681
91	250	384	38	—	416	1088
1892–96		(Only record: Prince Albert, 3)				
97	51	135	140	—	157	486
98	40	208	116	—	146	510
99	—	266	163	—	79	508
1900	—	140	28	—	145	313
Totals	1,230	7,809	665	888	1,770	12,365

from Chesterfield Inlet north to the base of Boothia Peninsula, more than 3,300 hides were turned in during the same two periods.

During the period of most successful muskox hunting, from 1888 to 1891, the Company's records show that of 5,408 hides traded, 3,084 were from the Mackenzie District, 1,078 from York Factory, 1,070 from the Athabasca District and 176 from Cumberland District. Unfortunately, detailed records for the Mackenzie River District are available only until 1885, so it is not possible to state definitely what post contributed the most skins after that date. Probably the majority of them were traded at Fort Rae, as the Indians trading into that post ranged far out on the barrens in a northeasterly direction to east of the Coppermine River, beyond Point Lake (Russell, 1898).

TABLE 2.—*Hudson's Bay Company, muskox fur returns, 1901–1916*

YEAR	ATHABASCA DISTRICT	MACKENZIE R. DISTRICT	SASKATCHEWAN DISTRICT	KEEWATIN DISTRICT	NELSON R. DISTRICT	TOTALS
1901	25	125	58	42	—	250
02	—	147	74	74	—	295
03	1	27	41	66	—	135
04	—	44	48	22	—	114
05	—	—	26	11	—	37
06	—	2	110	—	—	112
07	—	54	35	10	—	99
08	—	55	18	5	—	78
09	—	37	—	37	—	74
1910	8	81	130	32	—	251
11	—	94	—	—	58	152
12	—	43	66	—	171	280
13	—	2	—	—	145	147
14	—	18	—	—	—	18
15	—	5	—	—	77	82
16	—	1	—	—	—	1
Totals	34	735	606	299	451	2,125

That the intensive hunting had a serious effect on muskox numbers is demonstrated in Table 1 and 2. In successive years the number of skins bought diminished rapidly. The native hunters had to travel farther into the barrens each year to find the animals (Russell, *op. cit.*). In the region between Great Bear Lake and the Arctic coast, the species was virtually exterminated, although a small remnant population undoubtedly persisted in the Horton River area. Muskoxen were also eliminated in much of the country north and northeast of Great Slave Lake. There, too, remnant populations found safety—in the rough hilly country west and southwest of Bathurst Inlet and along the Thelon River. In the latter area, Eskimos and Indians penetrated less deeply for fear of encountering each other. The region between Chesterfield Inlet and Boothia Peninsula is as yet little known but the species did survive there. Recent occasional travelers in that region have seen as many as 40 muskoxen at a time.

In summary, when muskox hunting was made illegal in 1917, the species on the Arctic mainland had been greatly reduced in numbers from its abundance of former days and was restricted in distribution to three major refuges—the Bathurst Inlet region, the Thelon Game Sanctuary, and the base of Boothia Peninsula. There were other sites where muskoxen found some measure of security, such as in the Horton River region mentioned above and the hills northeast of Lake Clinton-Colden. Sightings in recent years in areas other than the above undoubtedly reflect the expansion and reoccupation of former ranges. The mainland population was estimated by R. M. Anderson (1930) to be 500 animals.

Hone (1934) collected the records of extermination or depletion of muskoxen for most of the islands in the Canadian Arctic. A summary of the information follows, including a number of Anderson's (1930) estimates.

On Banks Island the last sight-and-kill record was of a herd shot by Eskimos in the southeast corner of the island in 1911. They were believed to be the last of the species on the island.

On Victoria Island, in spite of hunting by natives and probably whalers, remnant herds were reported northeast of Prince Albert Sound at the time of protection in 1917. Anderson's estimate was 20 muskoxen.

Hone (1934) quotes Anderson's estimates of 1,500 muskoxen on Prince of Wales Island and none on Somerset Island.

Melville Island, one of the newly named group of Queen Elizabeth Islands, had been drained of many muskoxen by explorers from the time of Captain W. E. Parry in 1819–20. More than 600 were killed between then and 1917. Storkersen (1920) stated that about 4,000 muskoxen were present on that island.

Anderson's estimates of numbers of muskoxen on Bathurst and Cornwallis Islands were 1,500 and 200, respectively.

Devon Island supported a small population of muskoxen, particularly along the north coast. There had been some utilization of the species, but the 1930 population estimate was 200.

Muskoxen on Axel Heiberg Island have been rarely hunted, except at irregular intervals by early explorers and probably by Eskimos who crossed Ellesmere Island from Greenland. Anderson estimated that there were 1,000 of the ungulates on Axel Heiberg in 1930.

Utilization of muskoxen on Ellesmere Island predates historical records. The ancient Eskimo campsites near Bache Peninsula and on Fosheim Peninsula contain many muskox remains. No significant inroads into their numbers were made until polar expeditions, chiefly American, killed several hundred for food for themselves and their dogs, before and after the turn of the century. Greenland Eskimos armed with rifles also killed many. Using information from explorers and the R.C.M. Police, Anderson estimated 4,000 muskoxen on the island in 1930.

There is no historical information about muskox numbers on the islands of the Parry group north of Melville Island, apart from the record of Capt. F. L. M'Clintock, who killed five on Prince Patrick Island in 1857–59. There are no records, either, of muskoxen ever having occurred on Baffin Island. Lacking information, Anderson formed no population estimates for those islands.

On the Arctic islands the history of muskoxen follows a pattern similar to that of their mainland relatives: exploitation in some areas, extermination in others, and relative security in regions too remote for human travel.

PRESENT DISTRIBUTION

Arctic mainland.—In 1951, the Canadian Wildlife Service solicited the cooperation of the Royal Canadian Air Force aircrews in reporting observations of muskoxen during northern flights. The response was excellent. Many reports were turned in during the subsequent five years, particularly about animals seen on the Arctic Islands. Many other sources of information were tapped as well to obtain figures of muskox distribution and abundance. The annual game reports of the Royal Canadian Mounted Police detachments and written or oral reports by personnel of Federal Government Departments, the U.S. Fish and Wildlife Service, the Hudson's Bay Company, the Roman Catholic missions, bush pilots, and Eskimos, have all been compiled to present muskox distribution as accurately as possible within the limitations of the data.

The raw information is in the files of the Canadian Wildlife Service. Practically all the records were acquired between 1951 and 1955, but some unusual records received before and after that period add significantly to the total knowledge of muskox distribution. The observations were made chiefly during spring, summer and autumn months when the animals were on winter and summer ranges. Duplication of records has been carefully avoided.

The accumulated data are not numerically indicative, as most sightings were fortuitous. It cannot be assumed that all animals visible to the observers were counted, as sustained observation of the ground during flight is not usual, except by those undertaking specific surveys. However, the data are valuable for records of distribution, and sometimes provide the only indication that muskoxen exist in a region.

Muskoxen have been reported from many areas on the mainland, but concentrations are

evident in the Thelon Game Sanctuary and in the Bathurst Inlet region. Herds occur in lesser numbers in other locales described below.

Thelon Game Sanctuary.—Five summer survey ground parties have visited the Thelon Game Sanctuary in recent years. In 1951 and 1952, survey crews of the Canadian Wildlife Service counted 334 and 169 muskoxen, respectively. In 1954, a party of the Topographical Survey, Department of Mines and Technical Surveys, counted 170. All three parties traveled by canoe and saw the muskoxen from the canoes or when traveling on foot away from the river.

The other two parties were personnel of the Geological Survey of Canada surveying from helicopters. In the summer of 1954 the portion of the sanctuary lying in the District of Keewatin was examined, and 33 muskoxen were observed. In 1955 the survey's aerial activities were continued west of the boundary between Mackenzie and Keewatin Districts and 156 muskoxen were counted. From what is known of muskox distribution and movements in the sanctuary, it is unlikely that the 1954 count from the air duplicated that in 1955, and thus a total of 189 muskoxen was observed from helicopters.

In late March, 1956, the author counted the muskoxen in the eastern half of the sanctuary and recorded 192 of them.

None of the counts, either from the ground or from the air, can be regarded as absolute. However, it is significant that since 1952 the total numbers seen have ranged between 169 and 192, and that the high count of 334 in 1951 has not since been equalled. Quite probably the 1951 count included most of the muskoxen in the sanctuary. Based on all of these observations and considerations, the estimate of the present population in the sanctuary is placed at 350.

The second region of comparative abundance is the country between the Tree River and Bathurst Inlet and south of the Inlet to about the headwaters of the eastern fork of the Burnside River. Herds are known to exist near the Burnside, Hood, Wright, James, and Tree Rivers, and near Gray's Bay and Daniel Moore Bay. Numbers involved in the herds seen were as high as 50. A systematic coverage of the region by air has not yet been undertaken; the closest approximation to one was a survey flight made by R. Smith of the U.S. Fish and Wildlife Service, who flew across the region on a waterfowl survey in July, 1950. He recorded 209 muskoxen. An estimate of the total numbers in the area is 450.

As previously noted, the Hudson Bay muskox (*O. m. niphoecus*) was considered by Allen (*op. cit.*) to occupy, as part of its range, the northern half of Keewatin District, north of Chesterfield Inlet. Recent reports from that area are few, partly because fewer travelers pass through it and possibly because of the scarcity of muskoxen. Father Vanderbilt reported that the Ellice Hills had "some" muskoxen in 1944 and, in 1946, he stated that the Hayes River area supported at least 40. In 1948 the late Gunnar Ingebritson saw 50 muskoxen at the base of Simpson Peninsula (Banfield, 1951), and in 1949 the late Father Buliard reported seeing a muskox near Garry Lake. "Sandy" Lunan, Hudson's Bay Company post manager at Baker Lake, reported that in the spring of 1952 about 50 muskoxen were observed on the Meadowbank River. Eskimos reported tracks north of Chesterfield Inlet in the winter of 1954–55. The latest evidence comes from Andrew MacPherson (*in litt.*) who obtained muskox information from Eskimos and the resident missionary of Pelly Bay in the summer of 1956. Precise figures were not available, but the information indicated that the animals were quite common in the country between the Hayes and Murchison Rivers as well as at the head of Committee Bay. An aerial survey of the country described above was undertaken in late March, 1957, but no muskoxen were observed.

In the western Arctic, muskoxen have been sighted in several widely scattered localities north of tree line. In 1949, the R.C.A.F. reported seeing a herd of ten in the Bluenose Lake area north of Great Bear Lake. Herds were sighted in the same area by J. P. Kelsall in 1953, when he saw 86, and again in February, 1955. During the spring and summer of 1953, Eskimos told J. K. Fraser that they had seen a total of 39 muskoxen about 25 miles south of Paulatuk.

There have been recent reports of muskoxen southwest of Contwoyto Lake. In the winter of 1953–54, Eskimos saw 30 to 40 there and in December, 1955, a herd of 12 was observed in that locality by J. P. Kelsall.

Other points where muskoxen have been seen include: Lake Clinton-Colden, where herds were seen in 1952 and 1955; Regan Lake, where a herd of 19 was observed in 1955; Tourgis Lake, where 40 were seen in 1951 and two in 1955; the east end of Beechy Lake, where three herds were observed by a Geological Survey party in 1955; the Warren River area where two herds were seen by the Survey party and three bulls by the author, also in 1955; and south of MacAlpine Lake, where two were observed in December, 1955, by J. P. Kelsall. The mainland population is estimated to be about 1,500.

The general impression is that muskoxen are increasing on the mainland, but possibly the more frequent observations only reflect greater aerial activity. We can probably expect sightings within a few years of herds in the valleys of the Dubawnt and Kazan rivers. The recent decline in caribou numbers (Banfield, 1956) may have a serious effect on muskoxen, for Eskimos must seek alternative sources of food when they cannot find caribou. Clarke (1940) forecast this danger. Stringent enforcement will be required for adequate protection.

Arctic islands.—Figures of muskoxen on the Arctic islands are much more tentative than for those on the mainland. The observations for each island generally are few and in most cases involve relatively few animals. The R.C.A.F. supplied most of the sightings and, unless otherwise indicated, the ensuing observations are theirs. Officers of the R.C.M. Police and members of other government departments contributed significant records, however, and these are credited individually.

Each island for which records are available is considered separately in the following discussion. Islands which are omitted, such as King William, Victoria and Borden, have had no recent muskox records. Muskoxen have never been reported in historical times from Baffin Island or the adjacent Melville Peninsula.

Axel Heiberg: Fifty muskoxen were reported from the east-central part of the island in the summer of 1950, 30 from opposite Fosheim Peninsula, 10 inland from Mokka Fiord in July, 1953, and 30 from the same area in April, 1955.

S. D. MacDonald (*in litt.*) secured some excellent records from the east-central section while engaged in field work for the National Museum of Canada in 1955. During two flights over the area on May 13, 139 muskoxen were counted, including several calves. On July 19, four were seen southeast of White Mountain and two herds of 17 and 14, respectively, were grazing on Schei Peninsula. The total muskox population of the island is tentatively placed at 500.

Banks Island: The first observation for many years of a muskox on this island was obtained by T. H. Manning (1953) who saw one on September 2, 1952, in the Thomsen River valley. Two were reported by the R.C.A.F. in 1953. In the summer of 1954, a helicopter crew from the U.S.S. *Burton Island* reported seeing 30 in the northwest section of the island. McEwen (MS report, 1956)stated that in 1954 Eskimos saw two along the Masik River in April, two at Sacks Harbour in June and one at Storkerson Bay in December. Muskoxen may possibly have crossed from Melville Island to Banks Island (after 1911) and repopulated it, but it is more probable that remnant herds or individuals remained in security in the northern end of the island. Possibly 100 or more muskoxen live on Banks Island today.

Bathurst Island: Small herds of from 6 to 30 have been reported from central and southwest Bathurst Island. There are as yet no records from the northern section of the island. The total number on the island is estimated to be about 100.

Cornwallis Island: Cornwallis Island supports a small population of muskoxen. Numbers reported since 1952 have varied between 3 and 30. More than two herds have never been recorded at a time. There is a suggestion that the animals on the island have a marginal existence: an adult cow was found dead from what was believed to be starvation. The population estimate for the island is about 30.

DEVON ISLAND: Herds have been reported specifically from Grinnel Peninsula, Viks Fiord, Cape Sparbo, Dundas Harbour, Croker Bay and Erebus Bay, but probably there are herds in other parts of the island as well. Much of the eastern half of the island is covered with glaciers, reducing the total potential muskox range. Present information suggests that the muskox population on Devon Island is about 200, but this may be a minimum figure.

EGLINTON ISLAND: Small herds were sighted in the northern half of the island in the spring and autumn of 1952. Those animals probably are resident there, although it is quite likely that there is some interchange across the ice with Prince Patrick, Eglinton, and Melville Islands. A tentative population estimate is 30 muskoxen.

ELLESMERE ISLAND: This island supports probably the largest population of muskoxen in Canada, partly because of its size and partly because its low hills and plains form suitable range. Records indicate that most of the herds on the island are on the west side where good range is most extensive. Muskoxen have been reported from Craig Harbour west to Goose Fiord, and north to Vendome. Baumann Bay, Canon and Greely Fiords, Fosheim Peninsula, the Lake Hazen country and the northern tip of the island in the vicinity of Cape Joseph Henry, Cape Sheridan and M'Clintock Bay.

Major concentrations have been seen on Fosheim Peninsula, where 413 were counted in 1950, and in the Lake Hazen country, where the R.C.A.F. sighted 200 in April, 1956. Herds seen in other areas noted above contained 30 to 40 individuals.

Recent records for the eastern side of the island are notably lacking, but it is known that there are muskoxen on Bache Peninsula and near Archer Fiord. The generally mountainous and glacial nature of the northern and eastern portions of the island makes them less suitable ranges than the western part.

As with the other islands, it is difficult to estimate the total population of muskoxen on Ellesmere, but 2,000 is believed to be a reasonable figure.

GRAHAM ISLAND: A herd of 30 was seen on this island in the autumn of 1952 and smaller herds were reported there in the summers of 1953 and 1954. Earlier reports of muskoxen on the island, together with those above, indicate a resident population of about 30, with some movement across to Ellesmere Island.

ELLEF RINGNES ISLAND: In the spring of 1949, the R.C.A.F. sighted 21 muskoxen on the island, the first record for the species there. Resident weather station personnel reported that an adult bull, a cow and a yearling calf were near the station in 1951. S. D. MacDonald of the National Museum of Canada stated (*in litt.*) that no muskoxen were seen by him on Ellef Ringnes Island in 1954, but bits of wool, droppings and old tracks indicated that they did appear there occasionally. No population estimate can be given with the limited data available at present.

MELVILLE ISLAND: Herds of muskoxen have been sighted at widely separated places on this island, including Sabine Peninsula, Bridport Inlet, Winter Harbour, Dundas Peninsula and the western hilly portion of the island near Purchase Bay. The numbers involved were small, ranging from 3 to 30. The animals appear to be relatively more numerous near the head of Liddon Gulf, where three herds totaling 70 were reported on March 29, 1952. A preliminary estimate of the total numbers on the island is 200.

A muskox survey of Melville Island was undertaken in 1953, when A. G. Loughrey flew 700 miles in an R.C.A.F. aircraft over the island. None of the animals was seen on the survey.

PRINCE PATRICK ISLAND: Most of the recent records of muskoxen seen on this island have been centered around Mould Bay where a weather station is located. The numbers in herds observed have ranged from 3 to 31. Prince Patrick Island has no glaciers and much of the island's topography appears to be good muskox range. It is highly probable, therefore, that muskoxen may be found over most of it.

Reports of dead animals have been received from weather station personnel and from scientific investigators, S. D. MacDonald and Andrew MacPherson, who worked out from Mould

Bay. These observers attributed the deaths to wolf predation and natural causes. It is possible that starvation because of range over-utilization was a contributing factor.

It is difficult to assess the total number of muskoxen on the island but a minimum estimate is 200.

Prince of Wales Island: The only recent record for this island was given to the R.C.M. Police by some Eskimos who visited the island in the winter of 1951-52. They reported seeing "a few" muskoxen. It is not possible to give a population estimate.

Somerset Island: There are two recent records of muskoxen observed on the island, both for the period 1950–53. The first record was of a herd sighted at Creswell Bay; the second, an Eskimo report that they saw "many" on the northern part of the island. A population estimate cannot be given but it is possible that there are several hundred muskoxen on the island.

Stefansson Island: On July 22, 1954, two adults were observed by V. E. F. Solman on the northeast section of the island. There are no recent records for Victoria Island, but according to the Read Island Hudson's Bay Company post manager, there may be some in the extreme northeast corner. If that is so, there may be some exchange of muskoxen between Victoria and Stefansson Islands.

It is not possible to form an accurate determination of muskox numbers on the Arctic islands of Canada. The information available at present, however, suggests that about 3,500 animals are living there.

DISCUSSION

The information collated in this paper indicates that the total population of muskoxen in Canada today is about 5,000. Of this number about 1,500 are on the mainland and the rest on various islands as discussed in the previous section. Differences between these figures and those of Anderson prepared in 1930 reflect a more accurate assessment of Canadian muskox populations. Aerial and ground activities in recent years in the Northwest Territories have provided better data upon which to judge numbers and distribution of the animals.

Their distribution on the mainland reflects slowly increasing and expanding groups, often isolated, after 55 years of hunting for hides and meat and the subsequent 40 years of protection. Parts of their former range, such as that in the Yukon, probably will never be restocked naturally because of ecological barriers and barriers created by man. Undoubtedly, they could be re-established successfully if small groups were introduced into former ranges and given protection from predators, including man, during the first years of establishment. Other regions now devoid of muskoxen, such as the Dubawnt and Kazan river valleys, and the country east of Bathurst Inlet should eventually be restocked by natural spread.

There is no suggestion as yet that muskoxen have reached densities exceeding the carrying capacity of the range on the mainland, although this aspect must be investigated much further before final conclusions may be drawn. As they do not appear to move long distances to satisfy winter and summer range requirements, the number any area can support is probably small. Food production generally is low on the winter ranges and the nutritive quality of the winter foods particularly has not been found high.

On those Arctic Islands where muskoxen were killed for food and hides, the populations are increasing. The Lake Hazen country on Ellesmere Island is a case in point. The situation on Banks Island is more obscure; they appeared at the north end of the island after an absence of records for 41 years. The recent sightings may have been the result of an influx of a group from another island, such as Melville, or may reflect the increase of a remnant herd.

On Arctic islands where the muskoxen have been hunted relatively little they have probably reached an equilibrium with their environment. There is a suggestion that on Prince Patrick Island their consumption of food may have exceeded winter range production, as dead animals which appeared to have starved were found there in late winter. On Cornwallis Island a cow muskox was also found dead, which may have been prevented by hard snow from getting

sufficient food. Such occurrences emphasize the rather marginal existence of muskoxen in high latitudes.

Apart from the immediate effects of seasonal changes on the environment, the recent warming trend of the Arctic climate may be influencing animal distribution and numbers in ways not yet apparent. Future observations may shed light on the degree of this influence on muskoxen.

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SUMMARY

For fifty-five years, 1862–1917, muskoxen in Arctic Canada were hunted intensively for meat and hides. At least 15,000 skins were traded during this period. By the time complete protection was granted the species in 1917, only remnant populations existed on the mainland, in the Bathurst Inlet region, the Thelon Game Sanctuary, and the base of Boothia Peninsula. The mainland population in 1930 was estimated to be 500.

Populations on the Arctic islands suffered varying fates. They were virtually exterminated on Banks and Victoria islands and heavily hunted on Melville and Ellesmere islands.

Information gathered largely over a five-year period, 1951–1955, indicates that muskoxen are increasing in numbers and reoccupying much of their former range. This is true of the mainland where the population today is believed to be about 1,500, and of the Arctic islands whose populations are believed to total 3,500.

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LAND FORM AND CARIBOU DISTRIBUTION IN BRITISH COLUMBIA

BY R. Y. EDWARDS

Eight years of field work in southern and central British Columbia, often in areas inhabited by caribou (*Rangifer arcticus*), have suggested that the land form of mountainous caribou range is fairly constant as to type. In five areas containing caribou where the writer has done field work, summer range is at and above timberline on high foothill elevations adjacent to ranges of rugged mountains. These elevations may be described best as rolling mountains, typically with extensive flats and gentle slopes near their tops, and sufficiently high to support extensive alpine meadows above treeline. In four cases these caribou-inhabited elevations are part of the transition from British Columbia's Central Plateau to adjacent precipitous mountains. The exception is on and near the divide of the Rocky Mountains, in an area where the mountains are much less rugged than either to the north or south.

There has recently become available a unique atlas (BRITISH COLUMBIA ATLAS OF RESOURCES, Vancouver, 1956) which contains a land form map of the province, and another showing the areas inhabited by caribou in winter. These have provided an opportunity to test, on a large and general scale, conclusions reached from limited field experience.

The assistance of M. C. M. Matheson in compiling Fig. 1 is gratefully acknowledged. The British Columbia Natural Resources Conference kindly granted permission to use data from the ATLAS OF RESOURCES.

Field work.—Field work has been undertaken in five areas described below. These areas are indicated in Fig. 1.

A. Wells Gray Park: As noted previously (Edwards, Jour. Wildl. Mgt., 18: 521–526, 1954), "The ranges inhabited by these caribou comprise the less

precipitous foothill country bordering the mountains. The extensive meadows on the rounded foothill elevations seem better suited to this species than do precipitous slopes and permanent ice of the core of the Cariboo Mountains." These rounded mountains have extensive flats and gentle slopes supporting meadows and park-like forests of spruce and balsam fir above and at timberline, which is about 7000 feet. Adjacent lowlands, where suitable, are used in winter.

This choice of foothill topography is not absolute. Caribou may be found in the more precipitous areas to the north, but their numbers are relatively small. These animals appear to be wanderers, or small resident groups recruited from the larger population inhabiting the rounded summits and broad-bottomed valleys to the south.

B. Bowron Lakes Region: Caribou here inhabit high, rounded elevations

FIG. 1.—Relationship between caribou winter ranges (fine hatching) and subdued mountainous terrain (coarse hatching) in British Columbia. (*Data from British Columbia Atlas of Resources.*)

between the Interior Plateau and the northern massives of the rugged Cariboo Mountains. Here lowlands associated with the foothills are more extensive than those in Wells Gray Park. Caribou in winter are not confined to valleys, but descend to a rolling, forested plateau. The area inhabited by caribou is bounded on the north and west by plateau and on the east and south by precipitous mountains.

C. Northern Tweedsmuir Park: Here the land form pattern of the Bowron Lake Region is repeated. Caribou inhabit extensive meadows and barrens above timberline on rounded foothill elevations. To the south and west stand the rugged peaks and glaciers of the Coast Mountains, while the Interior Plateau, low and forested, extends to the horizon in other directions. Forested valleys, broad and poorly drained, penetrate the rolling upland ranges and are used by caribou in winter.

D. Southern Tweedsmuir Park: This area contains the southernmost caribou herds in western British Columbia. Precipitous mountains stand to the south and west, flat plateau to the east. Beyond the mountains to the south are large areas apparently suitable in land form which have had no caribou in recent time (see Fig. 1). The inhabited ranges are foothill elevations, less given to dome-like form than in the three ranges described above. Here, rather, is a more general uplift adjacent to the mountains proper. Meadows and rocky barrens are extensive above treeline.

E. Mount Robson Park: Most of the Rocky Mountains are high and precipitous. Associated with the low Yellowhead Pass, however, is an area of more subdued topography following the Continental Divide for some 100 miles. This area supports the southernmost caribou herds in British Columbia to be found east of the Rocky Mountain Trench. These are the herds inhabiting Jasper National Park, Mount Robson Provincial Park, and adjacent areas to the north. Here extensive flats and gentle slopes above timberline provide large unit areas of arctic-alpine habitat. High mountains lie to the north and south, to the west is the low Trench, and to the east lie dry forests descending to the Great Plains.

Atlas data.—The land form map used is remarkably detailed for its scale. Diagrammatic symbols resembling land forms cover the sheet. Since land forms may exhibit gradual change from plateau, through foothills, to mountains, the location of a line delimiting areas of subdued mountainous terrain is often a matter of personal opinion. Figure 1 indicates these as delimited by the writer and more or less agreed upon by a colleague who is a geographer.

Caribou winter ranges shown in Fig. 1 are based upon another map in the same atlas. Areas indicated must be taken as only approximate, for there is still much to be learned about caribou and their distribution in this province.

Figure 1 shows that most winter ranges are in or near areas of subdued mountainous land form, most of which are foothill areas. Exceptions are some ranges located in two parts of the province, the northeast and the southeast.

Of 44 winter range areas shown in Fig. 1, only six are more than 20 miles removed from foothill areas.

Discussion.—It is evident from Fig. 1 that caribou do not inhabit all areas with foothill land form. Such land form is but one requirement of caribou habitat in British Columbia. Presumably, those areas apparently suitable as to land form but without resident caribou lack other requisites of caribou environment. For instance, some foothill areas in the southwestern part of the province are inhabited by bighorn sheep (*Ovis canadensis*) rather than by caribou, and in one area elk (*Cervis canadensis*) have flourished following introduction there. In this region grasslands tend to penetrate into the higher elevations. These ranges are apparently ecologically unsuitable for a boreal animal such as caribou.

The eastern foothills of the Rocky Mountains in and near the drainages of the Peace River (Lat. 56° N) are also uninhabited by caribou. Here again, perhaps, the climate and vegetation are unsuitable. Adjacent plains to the east have a strong prairie grassland influence expressed in aspen parklands and agricultural soils. Bison (*Bison bison*) used to be found there (Wade, MACKENZIE OF CANADA. Blackwood, London, 1927) and remnant herds of elk still occur.

The Rocky Mountains south from about Lat. 52° N do not contain caribou. These mountains are high and precipitous, and do not anywhere offer extensive alpine meadows above timberline.

The isolated range of caribou on the Queen Charlotte Islands is of particular interest. Caribou are confined there to a small area with suitable land form. Temperatures are moderate and precipitation is high. It is possible that these animals are now extinct, as there is no recent information concerning their status.

The absence of caribou from Vancouver Island is probably related to glacial history. Many animals common on the mainland of British Columbia have not been found on Vancouver Island in historic time.

The three winter ranges in the northeast part of the province and remote from foothill relief are of special interest. These are the only three in the province at elevations below 2000 feet, and they are in the only large tract of land in the province with this low elevation. Elsewhere areas below 2000 feet are confined to narrow strips along the coast, or to the valley bottoms of the largest rivers. Perhaps caribou using these low ranges are of the woodland type. For years there have been unsubstantial reports of woodland caribou (*Rangifer caribou*) on these forested plains of northeastern British Columbia. This area is continuous with, and similar to, the coniferous Boreal Forest extending across Canada. Woodland caribou inhabit favored parts of this forest from Alberta to Newfoundland. Perhaps British Columbia contains the westernmost populations.

The occurrence of caribou in British Columbia south to the International Boundary (Lat. 49° N) appears to be a result, in part at least, of the high elevations attained by the southern mountains. The ATLAS OF RESOURCES Map No. 1, showing elevations throughout the province, indicates that few mountains in the northern half of the province exceed 10,000 feet above sea level. Over large areas elevations between 4000 and 6000 feet are predominant. In contrast, the Rockies and associated mountainous areas south of Lat. 54° N frequently

exceed 10,000 feet, while large areas are in the interval between 6000 and 10,000 feet. This fortunate condition of high mountains in the south is probably an important factor extending southward habitat suitable for caribou.

Summary.—Field work in British Columbia has suggested that mountainous areas inhabited by caribou (*Rangifer arcticus*) have a characteristic land form. Inhabited areas have rolling mountains with summits above treeline, or are elevated tablelands. These are often transitional areas, both in land form and in location, between plateaus and ranges of precipitous mountains. A test of this theory by comparing two maps of the province, one showing land forms, the other the areas used by caribou in winter, has substantiated the relationship. It is concluded that the so-called mountain caribou of British Columbia does not inhabit precipitous mountain masses, but rather finds suitable environment where rolling mountains and tablelands permit the existence of extensive arctic-alpine meadows with associated open subalpine forests.

Parks Branch, Dept. of Recreation and Conservation, Victoria, B. C. Received February 18, 1957.

OBSERVATIONS OF PRE-RUTTING BEHAVIOR IN NEWFOUNDLAND MOOSE

By Donald G. Dodds

Except for occasional groupings of animals during the winter months, moose are not considered to be a particularly gregarious species. Peterson (1955) believes the gregarious instinct to be less developed in moose than in any other North American hoofed wild animal. Hosley (1949) states that the gregarious instinct is feeble. For this reason, the following data, obtained during a study of Newfoundland moose in 1953, are of especial interest.

Behavior observed during these observations suggested the establishment of a breeding status in male moose prior to the rut. During this period, groups of from three to ten animals were commonly observed. The breeding status appeared to be formulated in three steps: (1) grouping of male animals, (2) belligerent action, (3) acceptance of status.

I am indebted to Mr. D. H. Pimlott and Dr. O. H. Hewitt, without whose assistance the study could not have been accomplished. Mr. Robert Folker helped considerably throughout the study period and made many of the observations.

Study area and methods.—The study area of 2.3 square miles was located approximately 15 miles south and east of Badger in central Newfoundland. It was partially burned in 1943 and again in 1950. Most of the area was cut prior to the 1943 burn.

Movements and behavior of the animals were studied by observation from four rock hills within the study area. With the aid of 7×50 binoculars and a

20× scope, moose were observed and identified with comparative ease throughout the burned area.

Early morning and late evening lookout periods were kept between June 20 and September 22. Occasional midday lookout periods were also made and a few animals were observed in the field during the course of the food habits portion of the study.

A total of 816 observations was made.

First indications of breeding behavior.—The first apparent indication of the rutting period was observed August 3 in the study area. On this day Folker watched an adult bull and a prong-horned animal standing and pushing each other, antlers together. The smaller animal was often forced to give way. This action continued for about 15 minutes. The animals then walked into cover. The first bull-cow pair was also observed the morning of August 3. On August 9, pushing was again observed between two adult bulls in the presence of a cow and her calf.

On August 14, I observed a cow and calf followed closely by two bulls who were making an effort to remain close to the female.

On August 17, I observed two bulls feeding in the open burn and stalked them. For nearly two hours I watched these animals from a distance of 50 to 70 feet. One bull was quite belligerent. Each time his partner moved adjacent to him, he lowered his head, swung his antlers and charged the other animal. The second moose turned and trotted aside on each occasion.

On August 18, Folker observed an adult bull, adult cow and calf. The bull was smelling of the calf's genitals and attempting to mount as the cow browsed nearby.

These were the first indications of breeding behavior. All the antlers were still in velvet and the hair forming the dewlaps on both sexes had grown to its maximum.

Observations of behavior leading to the breeding status.—Until the middle of August groupings of bulls were uncommon. Usually one, two or three animals were observed together. Between June 20 and August 18 groupings of three bulls occurred only six times while groups of four bulls were noted four times. No groups of more than four bulls were observed.

Yearling animals were found with cows, two-year-old bulls, adult bulls or alone during this period. This is notable, for when breeding begins, yearlings are complete outcasts, save for the occasional one remaining with a cow who had no spring calf at her side. Two-year-old bulls were also accepted only until breeding began.

Table 1 portrays the aggregations of animals observed between August 18 and September 15. By September 9, breeding had apparently begun. The groups were not located in feeding areas but were more often in the open burn areas of poor browse.

In each group listed some amount of interplay between bulls appeared. Usually one animal was "challenged" or faced by another. They then carefully

TABLE 1.—*Aggregations of moose observed between August 18 and September 15, 1953, near Badger, Newfoundland*

DATE AND GROUP NOS.	NO. OF MOOSE	NO. OF ADULT BULLS	NO. OF 2-YR.-OLD BULLS	NO. OF YEARLING BULLS	OTHERS
August					
18	4	4	0	0	0
21	3	3	0	0	0
22a	4	3	0	1	0
22b	4	4	0	0	0
24a	9	9	0	0	0
24b	5	5	0	0	0
27	10	7	1	0	2 (cow and calf)
28a	3	3	0	0	0
28b	5	5	0	0	0
28c	9	6	0	1	2 (cow and yrlg. cow)
28d	4	1	0	2	1 (cow)
28e	4	2	0	0	2 (cow and calf)
29	4	4	0	0	0
September					
1	8	5	0	1	2 (cow and unident.)
2	4	3	0	0	1 (unidentified)
9a	3	2	1	0	0
9b	3	3	0	0	0
11	3	2	0	0	1 (cow)
14	4	3	0	0	1 (cow)
15	5	1	1	0	3 (cow, calf and yrlg. cow)
Totals	98	75	3	5	15

placed their antlers together and pushed, one eventually giving ground. Often an animal was "challenged" by two or three in succession. It appeared that the animals were treating their antlers delicately. This may have been the case, as the first sign of loss of velvet was not until August 28. Presumably the antlers were still not immune to pain at this time. A behavior pattern somewhat similar to this is described by McMillan (1954) under a section entitled "Play."

The August 22*a* grouping was observed for about 20 minutes, beginning at 6:45 AM. The three adults, all with small antlers and presumably young animals (3–4 years), each faced the yearling in turn, placed their antlers to his spikes and pushed him backward. At the end of each match, the yearling began to feed but was faced immediately by another animal. On one occasion an adult butted the yearling from the rear. The young animal then turned and was pushed backward again. The bulls not taking part in the immediate match stood and watched the issue.

The August 24*a* group engaged in a constant shoving match, usually between one pair of animals at a time. Occasionally two pairs of animals were vying,

while others watched. The group remained engaged in this interplay for 50 minutes before a very large animal with more than 20 antler points walked away at 7:00 AM. Following his departure, the group split up gradually, leaving four animals feeding about the area. Due to the complex movement of the animals within the group, it could not be determined whether one bull was being singled out for attack more than others.

The August 24*b* (evening) group of five was located on the same site as the nine morning animals and acted similarly until visibility prevented observation.

The August 28*d* group of four animals is of particular interest. Two yearling bulls constantly challenged the adult male. The cow paid no attention to the action and strolled away. The adult bull, meanwhile, was kept busy pushing one yearling after the other away and then chasing the individual he had pushed. The yearlings continued to challenge the adult until they all disappeared into cover after the cow.

On September 1, the behavior of a yearling bull was most unusual. The yearling was first observed being pushed about by a small adult bull. A cow stood feeding in the alders behind the two bulls. Soon a larger adult bull approached and the young adult left the yearling to face the larger animal. As these two butted and pushed, the yearling ran up to the rear of the larger bull, sniffed and stomped his front feet. Then he reared up as if attempting to mount. Suddenly the yearling turned and trotted off to meet another adult bull which approached, in company with an extremely large bull and an unidentified animal.

On September 11, the only serious battle noted took place at 6:24 AM. This fight was between two large adult bulls, watched by a cow. Apparently the argument was not settled for all three animals walked away together after the bulls had battered each other for about 20 minutes. Here it may be that the two bulls were of the same breeding status.

By September 15, it appeared that a breeding status was fairly well founded. On this date a large adult bull was observed following a cow very closely. The cow's calf walked beside or ahead of her and both the cow and calf fed as they moved. The bull had his nose very close to or against the female's genitalia most of the time, stopping for an occasional nip of birch or cherry. As the animals stood atop a knoll, they were approached by a small cow (probably a yearling) and a two-year-old bull (prong-horned). The two-year-old animal followed the cow closely, also stopping to feed occasionally. When they came within a few yards of the three aforementioned animals, they stopped. The large bull left the cow and calf and walked between the two-year-old bull and the young cow. The bulls then faced each other, the younger animal taking a step or two toward the larger one. At the end of a two- or three-minute period the two-year-old turned and trotted a few yards away, stopped and watched. Immediately the large bull cast his full attentions on the small cow. She stood patiently as he lay his chin on her hips and rubbed sideways. After sniffing her for some time, he turned to feed, but kept close to her as they moved into heavy cover. The

two-year-old fed and watched from a distance, while the cow and calf moved far away by themselves.

By this time, yearling and two-year-old bulls were rarely observed with other animals. On September 16 a yearling bull was observed with an adult. D. H. Pimlott, who observed breeding behavior in the area after the author left, observed yearlings or two-year-olds with other animals on only three occasions throughout the remainder of September and October.

Summary.—Eight hundred and sixteen moose observations were made between June 20 and September 22, 1953, in central Newfoundland. Bull groupings were uncommon until mid-August. Between August 18 and September 15, 98 animals were observed in aggregations of from three to ten. Seventy-five of the total number in these aggregations were adult bulls, three were two-year-old bulls and five were yearling bulls. Behavior within the aggregations suggested the formation of a breeding status in male animals. Formation of this status was realized in three essential steps: (1) the grouping of male animals, (2) belligerent action between two or more males within a group, and (3) acceptance of status. Breeding appeared to have begun by September 9. Yearlings and two-year-old males were rarely observed with other animals at this time.

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DYES FOR STUDYING THE MOVEMENTS OF SMALL MAMMALS

By John G. New

The purpose of this study was to develop a technique for marking small mammals with dyes to facilitate the study of their movements. This objective included the important restriction of not handling the animal and thus avoiding many of the difficulties resulting from the use of the usual techniques.

Recent interest in the refinement of methods used to study home range in small mammals has led to numerous papers evaluating the techniques currently in use. Blair (1951, 1953), Hayne (1949, 1950), and Stickel (1954) have made major contributions in this evaluation. A need exists for new techniques that avoid the faults of live-trapping but provide the necessary information for assessing small mammal movements. The dye technique developed in this study attempts to overcome many of the criticisms leveled at live-trapping, but evaluation of this method certainly will demonstrate new difficulties, some of which will be pointed out in this paper.

Chitty and Southern (1954) and Davis, Emlen and Stokes (1948) have used dyes to study the movements of small mammals. In 1951, Eadie (unpublished) carried out some preliminary marking experiments with small mammals by feeding them sudan III. *Microtus pennsylvanicus* and *Blarina brevicauda* were recovered with pink-stained fat.

In this study an attempt was made to find a series of different colored dyes that could be used in studying certain phases of mammalian life history. No use of radioactive materials was made. The proposed use of dyes required that substances be fed orally so that feces, urine, pelage, or internal structures would become marked. A review of the literature of the use of dyes for internal and external staining was given in New (1956). Certified dyes were used whenever obtainable in this investigation.

I express my gratitude to Dr. W. Robert Eadie, under whose direction this study was conducted, for his encouragement and valuable counsel. Field work was supported during the summers of 1954, 1955 and 1956 by Graduate Student Honoraria awarded by the New York State Science Service. This assistance is gratefully acknowledged. Dr. Kile R. Barbehenn provided much encouragement and help through our many discussions of the problems involved.

STUDY AREAS

A large woodlot and a field were selected for the purpose of comparing two different ecological habitats for the one species, *Blarina brevicauda*, common to both.

McGowan's Woods.—This isolated woodlot of 23.8 acres is a second-growth, mixed hardwood stand, approximately 50 years old and located about two miles east of the Cornell University Campus. The ground cover varies in density; some areas are bare with no leaf litter while other areas have a deep layer of litter and much herbaceous plant cover. Many species of ferns are present.

The following small mammals of importance in this study were found in the woods: *Blarina brevicauda*, the short-tailed shrew was abundant throughout the woodlot during the entire period of this study with the exception of a few small areas; the deermouse, *Peromyscus leucopus*, was common, although apparently locally distributed.

Airport Field.—This area is located approximately five miles northeast of Ithaca, north and east of the airport. A plot of 10.7 acres next to the 12-acre plot used by Barbehenn (1955*a*, *b*) was studied intensively in 1954 and 1955. The construction of a small marsh by the New York State Department of Conservation inundated large parts of the best habitat so that it could not be studied in 1956. The field was in pasture some time prior to 1950 and is poorly drained. The plot is bounded on the north and west sides by extensive woods, on the east by a field similar to the one studied, and on the south by a marsh, with a wooded area beyond.

The following small mammals of importance in this study were found in this field. *Sorex cinereus* was trapped throughout the area. Evidence from scat sign did not indicate a high population, but 33 were trapped later. *Blarina brevicauda* and meadow mice, *Microtus pennsylvanicus*, were common throughout the field. This species and *Blarina* were frequently recorded at the same station, although *Microtus* was much more restricted in distribution than *Blarina*. Meadow mice occurred sporadically in the drier sections of the field where *Blarina* was often common, but the very driest sections were not utilized actively by either species as evidenced by scat deposition. Although a dump near this field harbored murine rats and mice, only one house mouse, *Mus musculus*, was trapped.

METHODS AND MATERIALS

Dyes available in various departments within Cornell University were obtained through the kindness of many people. I am especially grateful to Dr. Lowell D. Uhler who supplied many dyes. Other samples were received as industrial gifts from contacts made with several manufacturers. I am indebted to Mr. J. L. Legler of Allied Chemical and Dye Corporation and to Mr. C. B. Harris of E. I. DuPont de Nemours and Company for supplying many of the dyes tested. Other dyes were purchased. Dr. H. J. Conn of the Biological Stain Commission made many helpful suggestions.

Over 100 dyes were screened by feeding them to white mice and white rats. The method used and a list of the dyes tested in this study can be found in New (1956). Throughout these experiments there was no sign of abnormal behavior or toxicity in any animals.

In 1955, a 50-foot grid was established in McGowan's Woods and the Airport Field. In McGowan's Woods, 21 lines, each with 11 stations per line, (13.3 acres) were in use in 1955. This was expanded to include 275 stations (15.8 acres) in 1956. In the Airport Field, 15 lines with between 10 and 15 stations (10.7 acres) were worked in 1955, while in 1954, 8 lines with 14 stations (6.6 acres) were studied.

Bait boxes, made by cutting a wax-coated, quart milk container into two halves, were placed at each station in the grid. Boxes were always placed in runways, at tunnel entrances, or at other sites most likely to be visited by small mammals. Although this caused deviations from the 50-foot spacing it was felt that these divergences canceled out. The second half of the quart container was placed on a stake or hung in a bush to be used with dyed bait. The use of bait boxes followed the method used by Barbehenn (1955*a*) and suggested by Greffenius (1939) and Eadie (1948) as a means of studying small mammal populations.

The boxes were baited with a small amount of rolled oats. The following day all stations were examined and visitation by small mammals noted. The peculiar habit of defecating on clean surfaces provided a clear indication of an animal's presence at a station. Some confusion resulted from scats intermediate in size between those of *Blarina* and *Sorex*, but *Sorex* was uncommon in the woods and little activity was noted at the Airport Field. *Microtus* scats sometimes are confused with *Peromyscus* but the two animals did not occur together in this study. Chipmunks removed bait but seldom defecated at bait stations, and results of research in McGowan's Woods where chipmunks were numerous indicated that bait-station studies of chipmunks would be useless.

Bait.—Old Fashioned Mother's Oats was used as bait with few exceptions. This bait was cheaper than peanut butter, easier to distribute, eaten readily, and easier to mix with dye.

Dyes.—In this study, 46 dyes were tested in the field after laboratory investigation revealed that most of them would be satisfactory for such use. Details concerning the selection of these dyes and further information concerning manufacturer or chemical group will be found in New (1956). Dyes recommended for use are listed in Table 8 of this paper.

For field use, a dye was mixed with approximately 6 ounces of oat flakes. The exact amount of dye to be used results from experimentation by the worker. Between 500 mg. and 1 gm. was found to be sufficient, but this recommendation is made only for the small mammals investigated in this study. When the dye appears visually to be distributed evenly on the rolled oats, enough has been used. This can be confirmed by removing single flakes from different positions in the jar and immersing them in water. If the dye appears lumpy it should be pulverized before mixing with the bait. On several occasions dye was mixed with peanut butter. Preparation of dyed bait using peanut butter takes much more dye than with rolled oats. If the study were directed toward *Peromyscus* it might be worthwhile, but otherwise it is expensive.

Bait boxes and the use of dyes.—Dyed bait was placed at selected stations in the grid and undyed bait at all other stations. On any one day only a limited number of stations could be color-baited in order to keep them far enough apart to decrease the likelihood of an animal reaching two such stations during the same feeding period. Stations with the same colored

dye were usually more than 400 feet apart and never in a direct line. It was found that stations with different colored dyes could be closer together in the woods if *Blarina* alone was studied, because these animals moved shorter distances. The placing of the dyes can be determined only by experiment, because of variations between species and within species in different locations. One of the criteria used for determining the distance between dyes was the recovery of colored scats. If a different color appeared at a dyed-bait station it was evident that some animal could reach two different dye stations. In such cases, and in those where different colors appeared to approach a dye station too closely, the stations were moved farther apart. A dye was never placed at or near a station where a different color had been used, without allowing a 48-hour lapse of time. This was to assure independence of recovery records and was the minimum time for *Peromyscus* and *Microtus* since their metabolism is slower than that of shrews. A time lapse of 12 hours after dyed-bait removal was usually enough for *Blarina*, but to be on the safe side at least 24 hours were allowed to pass.

Only a small amount of bait was placed in the boxes in order to limit its attraction as food. The normal amount used was about one tablespoonful, but in McGowan's Woods twice this was utilized if baiting was done early in the afternoon. The time of day to bait was found to be important and was determined by the species present. A discussion of this problem is given in New (1956).

The day after baiting, all stations in the grid were visited and scat deposition recorded by species and color. Distances moved from the dyed-bait station were tabulated by taking the shortest distance between the dye station and the point of recovery. The data then were summarized for each species in a frequency distribution table of distances moved. If a scat recovered at the station was the same color as the dye previously placed there, it was recorded as zero distance moved. Normal and dyed scats were recorded for each species at any station where they occurred together. Uneaten, dyed bait always was removed carefully and every effort was made to prevent scattering it around the area.

Several methods of recording the data were used. Data sheets designed to met the requirements of this study will be found in New (1956).

RESULTS

Bait-station operation.—Barbehenn (1955*a*) has discussed the utilization of bait stations and various aspects of this technique. Additional comments will be found in New (1956).

Live-trapping indicated that three or four *Microtus* may use a single station. Barbehenn (*op. cit.*) has indicated that one *Blarina* may patrol six bait stations. In this study two *Peromyscus* were caught at the same time in the same trap. This type of data can be obtained through the use of dyes; but the data must be interpreted according to the length of time the dye is retained within the animal. Laboratory studies gave exaggerated results because the animals were forced to eat the dyed food in larger quantities than might be eaten in the field. The higher rate of metabolism in *Blarina* is responsible for a rapid egestion of the dye. Under field conditions, several live-trapped *Blarina* (allowed to eat the dyed oats in the trap and then released) had egested the dye within 6 hours. There was no evidence that the dye was retained more than 24 hours in this species and it is unlikely that it lasts 12 hours. Since the grid usually was visited once every 24 hours, an animal could ingest dye shortly after it was placed in the box or just before it was removed 24 hours later. A shrew might eat dyed bait just before its removal and defecate dyed feces at the station shortly after the bait was replaced. Unless this is kept in mind, the time the dye is retained will be overestimated. Egestion time is lengthened when large quantities of dyed bait are eaten; this is especially true in *Peromyscus* and *Microtus* because their metabolism is slower than that of shrews. When a deermouse feeds at a dye station shortly after dark, it will be eliminating the dye before dawn and there will probably be some recovery the next night. However, most recovery the second night is from mice that reach dye stations early in the morning, so that most of the dye has not been egested during the day. It was not uncommon to recover dye

TABLE 1.—*Frequency distribution of visitation per dye station; all data collected in 1955*

NUMBER OF STATIONS	MCGOWAN'S WOODS		AIRPORT FIELD	
	Blarina	*Peromyscus*	*Blarina*	*Microtus*
1 and 2	236 (90%)	80 (64.5%)	100 (57.8%)	39 (55.7%)
3	21	13	28	12
4	3	11	17	5
5	0	7	10	4
6	2	5	8	6
7	0	0	5	1
8	0	3	3	1
9	0	2	1	1
10	0	1	1	1
11	0	0	0	0
12	0	1	0	0
13	0	1	0	0

for a period of two nights when the dye was available only the first night. Thus, for *Peromyscus* it is safe to say that the dye will last for 36 hours or two nocturnal periods. Several instances of dye recovery for three nocturnal periods were recorded, but this was unusual. Snap-trapping data indicated the same thing. Many mice trapped the second night were marked internally. After *Microtus* has taken large amounts of dyed bait it will eliminate it during a 24-hour period. In several instances the dye lasted 48 hours. The dye may be utilized more rapidly in *Microtus* because this animal, being diurnal, is more active than *Peromyscus* and the total amount of food eaten is probably greater in *Microtus*.

The joint occurrence of two or more individuals of the same species at a station was recorded as follows: the capital letter represents the normal scat; the lower case letter signifies a dyed scat; two lower case letters indicate two different colored scats. All data were collected in 1955. For McGowan's Woods the figures were: Bb (184); Pp (78); Ppp (4). For the Airport Field the figures were: Bb (210); Bbb (3); BbMm (4); Mm (125); Mmm (10).

The numerous instances of two shrews occurring together are interesting, but mean little. It is probable that very few of these records actually represent two individuals, but rather the same individual that has returned to the box. The dye passes through quite rapidly, and during a 24-hour period there is ample time for revisiting stations within the home range. Nevertheless, several individuals may utilize a station during the same period.

The records for *Peromyscus* occurring together probably are more reliable since the dye is retained longer and the evidence from surrounding bait stations indicates that other mice are present. With the dye placements widely separated, it is interesting to note the few instances of recovery of two differently colored scats and normal scats at stations other than the dye station. The records of *Microtus* occurring together are probably at least 75 per cent correct. Three of the ten records of triple occurrence are questionable because the dye stations were close together and it was possible for an individual to reach more than one dye station.

Table 1 shows a frequency distribution of the number of stations visited per dye station for each species. The results cannot be assigned to individuals but rather represent what might be considered an index value. Although there is little doubt that in many instances the results do represent an individual's movements, there is no way of demonstrating this by using this technique.

TABLE 2.—*Number of stations visited in 1955*

	McGOWAN'S WOODS		AIRPORT FIELD		"t" TEST *Blarina*	
	Blarina	*Peromyscus*	*Blarina*	*Microtus*	Woods	Field
Total stations at which dye was placed	262	124	173	70	65	65
Total stations at which dye was recovered	407	335	454	185	101	158
Total stations visited	469	432	511	214	114	189
Average number of stations visited	1.79	3.48	2.95	3.06	1.75	2.90

In McGowan's Woods 90 per cent of the *Blarina* visitation was at one or two stations, in contrast to the Airport Field where only 57.8 per cent of the shrew visitation was at this number of stations. This appears to be related to the differences noted in distances moved and will be discussed later. *Blarina* and *Microtus* at the Airport Field and *Peromyscus* in McGowan's Woods showed a strong tendency to visit a greater number of staitons. The extreme recoveries of dyed scats at 12 and 13 stations, resulting from dye removal by *Peromyscus* from a single station, occurred in sections of the woods where deermouse activity was high. Ceratinly more than one individual was responsible for the activity in each of these instances. At least three different mice had been live-trapped at each of these stations.

The average number of stations visited gives some indication of the differences between species and within species in two habitats. In Table 2 the heading "Total stations visited" requires explanation. The "Total stations at which dye was recovered" includes only those stations where colored scats were found. In many instances dyed scats were collected at the dye station in addition to other stations. Frequently dyed scats were not recovered at the dye station, so that some compensation must be made for the fact that the animals responsible for these scats had to visit the dye station first. If a deermouse left dyed scats at three stations other than the dye station, these three stations would be included in the "Total stations at which dye was recovered." However, this animal had to visit the dye station first so it really visited four stations, not three. The extra station is added into the "Total stations visited." This last total is the one used for calculating "Average number of stations visited."

A "t" test was devised to determine whether there was a difference in the number of stations visited by *Blarina* in the Airport Field and in McGowan's Woods. Only 13 days were found in which the samples fulfilled the requirements of the test. Those days were selected that were the same for field and woods and on which the same number of dye stations were used. The "t" value was 4.11 and is highly significant at the 1 per cent level. In McGowan's Woods, *Blarina* visited fewer stations than at the Airport Field, and these results are also indicated in Table 2.

USE OF WATER-SOLUBLE DYES

Airport Field, 1954.—Fast green was placed at all stations in two adjacent lines 50 feet apart bordering a similar field on the east which was being used by Barbehenn (1955*a*). Safranin O (red) was placed at all stations in one line 200 feet west of the lines with fast green. The grid was checked daily and all visitation noted. A summary of results for dyed-scat recovery at 109 stations in the grid appears in Table 3. The average distances moved, including and excluding visitation to the zero station, are indicated in the last two columns of the table. These figures can be compared with those cited under work done during 1955, although the situations are quite different because of the manner of dyed-bait placement.

TABLE 3.—*Distribution of dyed scats at the Airport Field, 1954*

SPECIES	COLOR	DISTANCE FROM DYE STATION IN FEET							AVER. DIST. MOVED IN FEET	
		0	50	100	150	200	250	300	Incl. zero	Excl. zero
Microtus	Red	63	81	10	3	0	0	0	35.0	58.5
	Green	162	55	20	5	1	0	0	23.5	70.4
	Totals	225	136	30	8	1	0	0	28.0	64.0
Blarina	Red	27	37	21	4	2	0	0	54.4	77.3
	Green	45	14	8	3	2	1	2	42.7	106.7
	Totals	72	51	29	7	4	1	2	49.1	86.7
Sorex	Red	0	14	3	0	0	0	0	58.8	58.8
	Green	5	4	1	1	1	0	0	54.2	92.9
	Totals	5	18	4	1	1	0	0	56.9	68.8

It is obvious that most of the colored scats were recovered at or within 100 feet of the lines with dye. The extreme records for *Blarina* (250 and 300 feet) occurred on different days and required the animal to cross the line with red dye.

From September 17 to September 26 Barbehenn snap-trapped his 12-acre field and, as planned, I continued to place dyes at the stations indicated above. The purpose was to determine the interchange between the two contiguous areas and, particularly, to note ingress from my field into his. Thirty-four animals marked with dye were snap-trapped. The data are presented in Table 4. Data for one *Sorex* were lost but it was marked with red dye and had to move a minimum of 300 feet to reach the trapping area. All other animals were marked with fast green. It is interesting to note the activity in the area after the first two days of trapping. There was recovery of marked animals but no pronounced ingress from the area with dye stations. It is probable that some animals present in Barbehenn's field had home ranges that extended normally into the area with dye stations.

McGowan's Woods and Airport Field, 1955.—Dyes were placed at selected stations after the pattern of visitation was apparent. Dye stations were shifted frequently and distributed over the whole area. Spacing between dye stations has been discussed and all results presented here are based on the assumption that these stations were separated sufficiently to

TABLE 4.—*Penetration of dye into snap-trapped area based on trapped animals; Airport Field 1954*

SPECIES	DISTANCE in feet	DATE, SEPTEMBER 17	18	19	20	21	23	25	26	TOTALS
Microtus	50	2	5	4	3	0	1	1	0	16
	100	0	2	0	0	0	0	0	1	3
	150	1	0	2	0	1	0	0	0	4
	200	1	0	0	0	0	0	0	0	1
Blarina	50	0	1	2	0	0	0	0	0	3
	100	0	2	0	0	0	0	1	0	3
	200	0	1	0	0	0	0	0	0	1
Sorex	50	0	2	0	0	0	0	0	0	2
	300*	–	–	–	–	–	–	–	–	1

* Data lost.

TABLE 5.—*Frequency distribution of dyed-scat recovery for various distances in 1955*

DISTANCES in feet	MCGOWAN'S WOODS		AIRPORT FIELD	
	Blarina	*Peromyscus*	*Blarina*	*Microtus*
0	200	27	116	41
50	112	68	94	48
71	33	50	71	25
100	12	17	50	15
112	20	56	51	23
141	9	19	10	5
150	1	12	14	4
158	6	8	13	13
180	3	18	9	2
200	2	14	7	2
206	3	6	6	4
212	0	3	1	2
224	3	6	4	0
250	1	5	1	0
255	1	7	2	0
269	0	1	1	1
283	0	0	1	0
292	0	3	0	0
300	0	1	1	0
304	0	6	1	0
316	0	1	0	0
335	0	1	0	0
354	0	3	1	0
412	1	0	0	0
430	0	1	0	0
461	0	2	0	0
Total dyed scat recovery	407	335	454	185
Total dye stations	262	124	173	70

prevent the use of several dye stations by one individual during the same feeding period. Certain stations were used as dye centers for several days to see how the pattern of dye distribution would vary. No experimental design was employed to standardize the collection of data in this experiment. Confusion was sometimes caused by the appearance of colored feces of insects, the colored remains of the body fluids of squashed invertebrates, colored urine of small mammals, and scats of small mammals colored by their natural foods. By moistening the scat one can observe whether dye is present because it usually will dissolve out. Dried scats also should be treated in this way.

Table 5 is a frequency distribution of dyed-scat recovery for the Airport Field and McGowan's Woods. All data presented in Table 6 are derived from this information. A "*t*" test, devised to compare distances moved for *Blarina* in the Airport Field and McGowan's Woods, gave a value for *t* of 3.45 and is significant at the 1 per cent level. Only 13 days could be used in this test. The mean distance derived from the data used in this test also appears in Table 6 and is listed as "Mean dist. *t* test." No statistical evaluation of the rest of the information in this table is warranted because the data were not collected uniformly. The data have been

TABLE 6.—*Average distance moved (in feet) and foraging area (in acres) based on dyed-scat recovery; data collected in 1955*

	MCGOWAN'S WOODS *Blarina*	AIRPORT FIELD *Blarina*	MCGOWAN'S WOODS *Peromyscus*	AIRPORT FIELD *Microtus*
Mean dist. *t* test	53.7	101		
Range in acres	0.05–0.21	0.19–0.79		
Mean dist. incl. 0	41.5	73.6	117.2	75.1
Range in acres	0.01–0.12	0.098–0.39	0.25–0.99	0.1–0.4
Mean dist. excl. 0	80.4	99.0	127.5	96.1
Range in acres	0.12–0.47	0.19–0.71	0.29–1.17	0.17–0.67
Mean dist. excl. 0				
Radius plus 25′	105.4	124	152.5	121.1
Diameter plus 50′	130.4	149	177.5	146.1
Range in acres	0.31–0.8	0.4–1.1	0.57–1.7	0.38–1.1

presented in several ways because the best method to use is not clear. These data are obviously based on an unknown number of individuals. In addition, sex, age, reproductive condition, and similar facts are not known. The use of the mean distance exclusive of zero station appears justified, because recovery at the zero point is not distance moved away from the dye station. The use of the mean distance exclusive of zero, with the addition of half the distance to the next station, appears compatible with the findings of Stickel (1954).

Areal estimates of home range using linear distance have been criticized because the home range is seldom circular (Blair, 1953). In addition, it is probable that all the area within a circle is not traversed and certainly some parts of the home range are frequented more than others. However, this criticism also can be leveled at home range estimates obtained by the boundary strip method, since they too include areas not traversed by the animal. Those animals restricted to runways might be recorded as having the same areal home range as others not restricted to runways. With these limitations in mind, it appears that the estimates obtained by using the "Mean dist. excl. 0" or the "Mean dist. excl. 0, Radius plus 25′, Diameter plus 50′" give values most consonant with the data found in the literature. Blair (1940*a*, *b*, *c*, 1942), Burt (1940), Gottschang (1950), Hayne (1950), Howard (1949), Manville (1949), and Smith (1942), using an areal method, present home range estimates for *Blarina brevicauda*, *Peromyscus leucopus*, *P. maniculatus gracilis*, *P. m. bairdii*, and *Microtus pennsylvanicus* that are consistent with the results of this work. Linear home range estimates presented by Burt (1940); Davis, Emlen and Stokes (1948, for the Norway rat); Dice and Clark (1953); Manville (1949); Nicholson (1941); Smith (1942); and Stickel (1946) for the species indicated above are also in accord with the results of this work. Interpretation of data presented in this paper as indicating home range estimates is not justified because, undoubtedly, in many cases more than one individual was responsible for the distribution of the dye. For this reason the term "foraging area" is used in the heading of Table 6. The data were compared with home range statistics because no other type of information was available. The intended use of these figures is merely to arrive at a parameter that can be used to compare different areas and possibly species. Whether the index values obtained in this study are homologous to the home range data cited above remains to be demonstrated. Future research along these lines seems warranted.

Table 7 summarizes the per cent dye recovery at various distances for the species studied. Accumulated percentages are given until that distance is reached where at least 90 per cent of the recoveries were made. Also given are the number and per cent of dye stations that were not revisited during the feeding period. This means that the animals involved deposited scats

at other stations, never returning to the zero station. This figure is the difference between "Total stations at which dye was recovered" and "Total stations visited." An interesting point to note is that dyed *Peromyscus* scats seldom were recovered at the zero station whereas this was usual for *Blarina* and *Microtus*, although there is variation in that respect.

Data collected for *Sorex* include the following recoveries: 1 (200′), 1 (206′), 2 (250′), 2 (255′), 1 (316′), and 1 (354′). Although *Sorex* scats can be mistaken for those of *Blarina*, the recovery of a snap-trapped *Sorex cinereus* with red dye 300 feet from the nearest dye station indicates that this tiny animal does traverse such distances.

Recommendations for the use of specific dyes.—Table 8 lists the dyes recommended for different species. Substitute dyes are also listed in order of recommendation. Most dyes have Color Index numbers and these appear after the name of the dye in Table 8. Color Index numbers are listed in Cady (1955), Conn (1953) and Venkataraman (1952). Several food dyes were obtained too late for extensive use, but those that appeared favorable are listed as possible dyes for future testing. Ponceau 3R and amaranth may be more desirable than dyes now recommended because they can be obtained in a certified form. Indigo carmine and wool violet have not ben tested with *Microtus* and might prove very satisfactory. Indigo carmine is recommended for further testing with *Peromyscus* because, if satisfactory, it is cheaper than fast green, is certified, and gives good results with *Blarina*. Hematoxylin was never eaten when placed at stations that were used actively by *Peromyscus*. It was eaten readily by *Microtus* but was difficult to detect in scats and is not recommended.

DISCUSSION

Many criticisms leveled at live-trapping cannot be applied to the use of dyes and bait-station operation. Movements are not restricted by traps, individuals are not subjected to exposure, reproductive habits remain unimpaired, and social relationships continue essentially normal. However, the influence of the bait station in the environment remains to be clarified. Further studies of species interaction and differential use of stations by various age groups

TABLE 7.—*Per cent of dyed-scat recovery at or less than distance indicated*

DISTANCE in feet	MCGOWAN'S WOODS		AIRPORT FIELD	
	Blarina	*Peromyscus*	*Blarina*	*Microtus*
0	49.6	8.0	25.6	22.2
71	85.6	43.2	62.0	62.0
112	92.8	65.1	84.3	82.6
141		70.7	86.3	84.9
150		74.3	89.4	87.0
158		76.7	92.3	94.1
180		82.1		
200		86.3		
206		88.1		
212		88.9		
224		90.8		
Total stations at which dye was recovered (*A*)	407	335	454	185
Total stations visited (*B*)	469	432	511	214
B minus *A*	62	97	57	29
Per cent of dye stations not revisited	23.7	78.2	32.9	41.4

may show that specific and interspecific social relationships are affected by the presence of bait stations. Differential response to live-traps has been demonstrated for marked and unmarked animals by Tanaka (1956) and Barbehenn (1955*a*). There appears to be no evidence from snap-trapping data in this study to indicate differential response to bait boxes either for sex or age group. Criticisms of the dye technique include: possible toxic effects of dyes, differential acceptance by individuals, exhaustion of the dye either by inadequate feeding or by defecation before the actual foraging range has been revealed, and restriction of movements because of attraction to bait boxes for food. Another problem arises when species with similar scats are present in the area. The successful use of dyes with *Blarina* has been demonstrated. The mortality factor is eliminated, and six dyes provide the worker with an ample number of colors to study these animals on large areas.

Another criticism of data collected by the recovery of dyed scats is the lack of information concerning the individual or individuals responsible for the distribution. The live-trap method provides data on sex, age, reproductive condition, pelage, and other features not known when using the dye technique. Yet, if the animals are to be left undisturbed, rapid accumulation of data on distances moved can be made with dyes but not with traps. Evidence from this study, to be reported in another paper, does indicate that individuals may visit up to eight stations within a short period of time and may also move considerable distances. Much of this information is the same type that is accumulated by live-trapping. Results using water-soluble dyes are consistent with estimates of home range, both areal and linear, in the

TABLE 8.—*Water-soluble dyes recommended for use*[*]

DYES	*Blarina*			*Peromyscus*			*Microtus*		
	R	S	T	R	S	T	R	S	T
Red:									
Rosanalin hydrochloride (676?)	1	–	–	1	–	–	1		
Rhodamine B extra (749)	–	2	–	–	1	–	–	1	
Ponceau 3R (80)	–	1	–	–	–	1	–	–	1
Amaranth (184)	–	–	1	–	–	2	–	–	2
Alizarin red S (1034)	–	–	–	–	–	3	–	3	
Safranin O (841)	–	3	–	–	–	–	–	2	
Orange:									
Orange I (150)	1	–	–	–	–	1	–	–	1
Orange II (151)	–	2	–	–	–	2	–	–	2
Yellow-Green:									
Fluorescein (766) (spirit-soluble)	1	–	–	–	–	1	–	–	1
Blue-Green									
Fast green FCF (none)	1	–	–	1	–	–	1		
Brilliant blue FCF (none)	–	2	–	–	–	2	–	2	
Indigo carmine (1180)	–	1	–	–	–	1	–	–	1
Patent blue (712)	–	3	–	–	1	–	–	1	
Blue:									
Niagara sky blue 6B (518)	1	–	–	–	–	1	–	–	1
Violet:									
Wool violet 4BN (697)	1	–	–	1	–	–	–	–	1
Hematoxylin (1246) (dark crystals)	–	1	–	–	–	–	–	1	

[*] R, recommended; S, a tested substitute; T, insufficient testing. Numbers indicate assessed order of usefulness for the species listed.

literature. If both types of data represent the same facts, and it is not at all certain that they do, parameters derived from data collected by using dyes could be determined and used to compare results from different areas. Index values for distances moved or number of stations visited may be found just as satisfactory as home range data now collected with live-traps.

A very serviceable method for studying ingress, egress or interchange between areas was the technique used in 1954 at the Airport Field where the same dye was placed at each station in one line. The continued operation of bait stations in a trapped out area, while using different colored dyes around the periphery of the area, would reveal the direction and duration of ingress. Interchange between two habitats could be studied by using a line of dye down the edge of the two habitats or a different color in each of the environments. Recovery of dyed scats would indicate the direction and frequency of interchange.

The differences found in distances moved and number of stations visited by *Blarina* at the Airport Field and in McGowan's Woods seem real. Snap-trapping results indicated a difference in population level (New, 1956). In McGowan's Woods where the shrew population was high, the distances moved were less than those recorded for Airport Field *Blarina*. The reason for the difference in distance moved was not investigated, but Stickel (1948) found through live-trapping that *Peromyscus leucopus* living in upland woods had a significantly larger cruising range than those living in the bottomlands where the population level was higher. Blair (1940*a*) found that male meadow mice had smaller ranges in moist than in dry grassland. No ecological investigation was made to reveal the differences between the areas in this study. It seems likely, however, that McGowan's Woods was the better habitat because of its better-drained, more friable soil and numerous rotten stumps, which would be ideal for shrews. In addition, the soil in this area is known to support a large earthworm population (Eaton and Chandler, 1942) and arthropods of many types are plentiful. No study comparable to that of Eaton and Chandler (*op. cit.*) has been made at the Airport Field. A big difference in food supply would permit a larger population of shrews to live in the woodland, and the resultant crowding might be responsible for the reduced foraging range. Thus the use of dyes has revealed a difference in two populations, and for a species difficult to study by live-trapping.

An extension of the dye technique to other mammals such as rabbits and deer would give the wildlife manager another tool. Here the technique might work best when snow cover is present. Dyes mixed with food pellets could be distributed in rabbit habitat. What effect coprophagy would have on the dyes remains to be seen. In an unintentional experiment a snap-trapped *Blarina* that had eaten fast green was fed to a pine snake, *Pituophis m. melanoleucus*. The dye was passed in the feces but seemed less intense. Dyes might be placed in salt blocks, or capsules containing dye could be mixed with supplemental feed to be given to deer.

SUMMARY

A 50-foot grid was established in a field and in a woodlot. Half of a wax-coated quart milk container was baited with rolled oats and placed at each station. The boxes served to protect the bait and as receptacles for feces. Visitation, as evidenced by deposition of scats (feces), was recorded by species. The introduction of dyed bait at certain stations enabled the author to record distances moved from the station with dyed bait, when colored scats were recovered at various stations in the grid. From a frequency distribution of distances moved, it was demonstrated that the short-tailed shrew, *Blarina brevicauda*, ranged shorter distances in the woodlot than in the field. Similar studies with *Microtus pennsylvanicus* and *Peromyscus leucopus* were conducted. Deermice ranged greater distances than either shrews or meadow mice and only 8 per cent of the dyed scats for this animal were recovered at the dyed-bait station. The same figures for the other species are: *Microtus*, 22; *Blarina*, field—26, woods—50. Areal and linear estimates based on modified averages of distances moved, compare favorably with home range data from the literature. A list of dyes suitable for each of the species studied is presented with suggested alternates.

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BREEDING SEASON AMONG MAMMALS IN THE LOWLAND RAIN-FOREST OF NORTH BORNEO

BY PHYLLIS WADE

Two recent expeditions of the Chicago Natural History Museum (Davis and Inger, 1950; Inger, 1956) collected mammals in the lowland evergreen rain-forest of eastern North Borneo. The collecting localities lay between 4° and 6° N. latitude, from Sandakan south to the Kalabakan River. The reproductive organs of each female collected were examined in the field and instances of pregnancy and lactation were recorded. No attempt was made to estimate the stage of pregnancy but all pregnant uteri were preserved. Except for the first week of June, when both parties were shifting localities, the expeditions were active in the field from April 9 to August 19 in 1950 and from April 22 to August 12 in 1956. Excluding bats and most of the larger mammals with very long gestation periods (elephant, rhinoceros, sambar deer, temadau, pig, bear, and orangutan), the data cover 25 genera distributed among the following five orders: primates, 6; rodents, 8; insectivores, 1; carnivores, 8; artiodactyls, 2. A total of 201 adult females was examined, and 51 pregnancies recorded. Detailed data for each species will appear in a general report on the mammals of North Borneo being prepared by D. D. Davis.

Environmental conditions in this area are relatively constant throughout the year. There is no marked dry season and the forest is always green. Rainfall varies considerably over fairly short distances but the mean monthly rainfall at Sandakan, averaged over a period of 23 years, is probably representative of

eastern North Borneo (Fig. 1). The annual total is 134 inches; January is the wettest month with a rainfall of about 21 inches, and April the least wet, with a rainfall of 6 inches. Mean monthly temperature at Sandakan varied no more than 3°F. over the five-year period 1950–1954.[1] Over an eight-year period (1947–1954) 2 PM mean relative humidity at Sandakan varied about 8%,[1] although relative humidity in the rain-forest is higher and varies within narrower limits at ground level. Maximal variation in day length at 5° N. latitude is about half an hour (Baker, 1937).

The literature on breeding seasons among vertebrates in tropical aseasonal environments pertains largely to birds, and most of the work has been done at the specific level. Thomson (1950), in an introductory review to a series of papers on the breeding seasons of birds in different parts of the world, states that "breeding seasons are an annual event in the life of most mature birds," even among those inhabiting tropical aseasonal environments although more

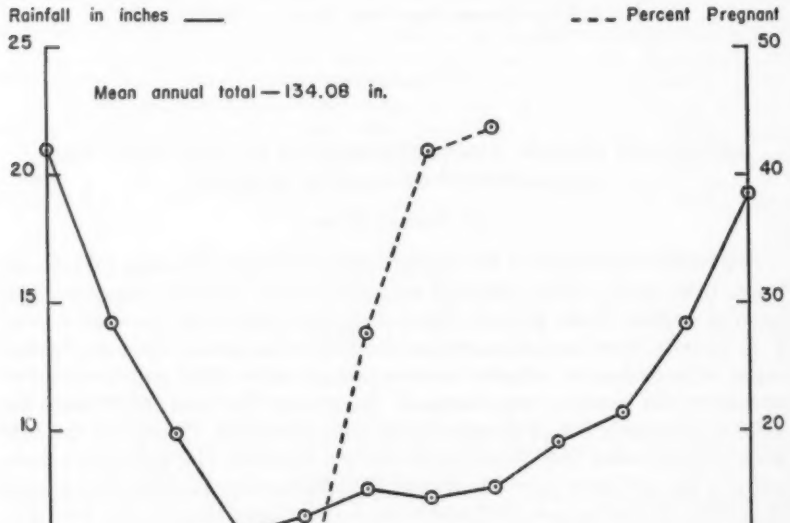

FIG. 1.—Pregnancy rate for all adult females superimposed on mean rainfall figures for Sandakan, North Borneo.

[1] Summaries of Observations. 1946–1954. Malayan Meteorological Service.

TABLE 1.—*Pregnancy rate for collection as a whole*

MONTH	NO. ADULT ♀♀ COLLECTED	NO. PREGNANT	PREGNANCY RATE
April	23	0	0.0
May	45	3	6.6
June	58	16	27.6
July	43	18	41.9
August	32	14	43.8
Total	201	51	—

exceptions occur in such areas. He concluded that the environmental factors operating at the beginning of the breeding cycle are so timed as to allow each species to produce its young during a period most favorable for survival. These factors differ for different species in different parts of the world.

Baker (1947) studied the breeding activities of a fruit bat, an insectivorous bat, a passerine bird and a lizard in the New Hebrides, and found that each had an annual breeding season, although the lizard exhibited a less marked one. The onset of breeding fell at a different time of the year for each species. The fruit bat produced its young in August; the insectivorous bat in December; the bird in July. The lizard bred all year round, but breeding was more active in November and December. Baker concluded that the environmental factors regulating the breeding seasons were of an unknown kind.

Harrison (1952) concluded that there is no breeding season among four forest species of *Rattus* in Selangor, Malaya. He stated that the pregnancy rate showed a bimonthly correlation with the lunar cycle and a non-seasonal, non-rhythmic correlation with monthly fluctuations in rainfall for any given year. In a later study Harrison (1955) added new data for insectivores and rodents. He reaffirmed his earlier conclusion that no breeding season exists for the mammals studied, but stated that the pregnancy rate for each species averaged by units of more than one month showed "irregular variations broadly related to rainfall which, in turn, is irregular."

Our data for the Bornean mammals are too limited to permit analysis at the specific level. Therefore, the pregnancy records for the collection as a whole were tabulated by month (Table 1). The resultant combined pregnancy rate shows a dramatic rise from zero in April to 43.8 in August. This indicates that there is a breeding season among the mammals collected. Neither its length nor its cyclical character can be determined since neither expedition was in the field a full year.

To permit further analysis the data were separated into two groups by length of gestation period. The major part of the collection is made up of small mammals with gestation periods of 60 days or less (data on gestation periods from Kenneth, 1953, and Hendrickson, 1954) (Table 2). The pregnancy rate for this group alone is as follows: 0, April; 0, May; 15, June; 37.2, July; 28.1, August.

TABLE 2.—*Monthly incidence of pregnancy among mammals with gestation periods of 60 days or less*

GENERA	TOTAL ADULT ♀♀ COLLECTED	NO. PREGNANT					NO. SPECIES
		Apr.	May	June	July	Aug.	
Tupaia	42	–	–	2	7	1	3
Tarsius	4	–	–	–	–	2	1
Callosciurus	33	–	–	2	3	2	2
Nannosciurus	9	–	–	–	2	–	1
Tomeutes	31	–	–	2	–	2	2
Ratufa	8	–	–	2	–	1	1
Paralariscus	1	–	–	–	1	–	1
Trichys	1	–	–	–	–	–	1
Rattus	7	–	–	–	1	–	4
Petaurista	1	–	–	1	–	–	1
Echinosorex	5	–	–	–	–	1	1
Paradoxurus	6	–	–	–	–	–	1
Viverra	2	–	–	–	2	–	1
Herpestes	1	–	–	–	–	–	1
Hemigalus	5	–	–	–	–	–	1
Arctogalidia	1	–	–	–	–	–	1
Felis	1	–	–	–	–	–	1
Martes	1	–	–	–	–	–	1
Mydaus	1	–	–	–	–	–	1
Total	152	0	0	9	16	9=34	26

The absence of any pregnancies in both April and May for this group strongly suggests that breeding is seasonal for most of the small mammals. There is some evidence, however, that not all species breed during this period. No pregnancies were found among 15 adult females of the squirrel, *Tomeutes hippurus pryeri*, collected between April 26 and August 5. Also, of 15 adult female civets collected, covering 5 genera, pregnancy was found only in *Viverra tangalunga tangalunga*.

The second group includes the remainder of genera with gestation periods far in excess of 60 days (*Tragulus*, 120 days; *Muntiacus*, 180± days; primates, up to 200 days) (Table 3). No pregnancies at all were found in April but only six females of this group (2 *Presbytis* and 4 *Tragulus*) were collected during that month. The pregnancies in May represent *Presbytis aygulus, Hylobates moloch* and *Tragulus kanchil*, all medium-sized animals with long gestation periods; none of the three individuals was near term. Incidence of pregnancy in *Tragulus* increased steadily from April to August (none of the 4 collected in April was pregnant; 1 out of 4 in May; 4 out of 6 in June; 2 out of 2 in July; and 2 out of 2 in August). These bits of evidence suggest that the onset of breeding may be stimulated at about the same time as in the other group, although our data are inadequate to substantiate this.

TABLE 3.—*Monthly incidence of pregnancy among mammals with gestation periods greatly exceeding 60 days*

GENERA	TOTAL ADULT ♀♀ COLLECTED	NO. PREGNANT					NO. SPECIES
		Apr.	May	June	July	Aug.	
Presbytis	10	–	1	–	–	2	3
Macacus	3	–	–	–	–	1	1
Hylobates	5	–	1	1	–	–	1
Nasalis	1	–	–	–	–	–	1
Tragulus	16	–	1	4	2	2	2
Muntiacus	4	–	–	2	–	–	1
Total	49	0	3	7	2	5=17	9

Superimposing the pregnancy rate for the entire collection upon the mean monthly rainfall figures for Sandakan (Fig. 1), a correlation appears with the period of minimum precipitation. It is interesting that no pregnancies occurred in April, the least wet month of the year, but incidence of pregnancy increased steadily thereafter. The young would be produced at the end of the less wet season and into the wetter season depending upon the length of the gestation period. Fluctuations in temperature, humidity and day length are too small to produce any significant correlations.

It may be concluded that (1) breeding is seasonal among most of the mammals of the evergreen rain-forest of eastern North Borneo, and (2) that the onset of breeding is correlated with the period of minimum precipitation.

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Division of Anatomy, Chicago Natural History Museum, Chicago 5, Illinois. Received March 30, 1957.

GENERAL NOTES

BREEDING OF AN IMMATURE WILD BABOON

In the course of investigations on Gold Coast primates, numerous cynomorph monkeys have been killed, among them a number of gravid and nursing females. In every case except one, the females had already acquired the full adult dentition. The single exception was a young female baboon, *Chaeropithecus anubis choras*, collected 3 miles southeast of the Shai Hills in southern Ghana on February 28, 1957. The specimen was well-grown, exceeding in weight and in body length an adult obtained from the same locality a month previously. The basion-prosthion line in the skull measures 117 mm. as compared to 123 mm. in the adult from the same locality. The third upper molar is entirely within the alveolus. The third lower molar has the talonid within the alveolus, but the two anterior cusps had cut the gum and were in use. The specimen had an infant at breast, judged, by comparison with captive specimens, to be not more than two weeks old. From the condition of the teats of the mother, it was clear that this was her first offspring.

In captivity, monkeys frequently fail to erupt the third molars throughout a long life, and may even breed in that condition. This, however, is almost undoubtedly due to the conditions in which they are kept. In a collection of over 300 skulls from West Africa, belonging to various species, I have no adult wild-killed specimens which lack a complete dentition. In the case of this female baboon, it seems clear that the third molars would have erupted in the normal way, and the open sagittal and lambdoid sutures confirm the immaturity of the specimen. The specimen is numbered CAC/7 and is stored at Achimota.—A. H. Booth, *Dept. of Zoology, University College of Ghana, Achimota. Received May 31, 1957.*

TADARIDA AND *MYOTIS* OCCUPYING CLIFF SWALLOW NESTS

On March 20, 1957, H. P. Kirby and the writer found Mexican free-tailed bats, *Tadarida brasiliensis mexicana* Saussure, and cave myotis, *Myotis velifer incautus* (J. A. Allen), occupying abandoned nests of the cliff swallow, *Petrochelidon pyrrhonata*, under a high bridge over a stream, locally known as Pinto Creek, 18.6 miles southeast of Del Rio, in Kinney County, Texas. The typical mud cliff swallow nests were located in the corners of cavities of "inverted box" shape formed by the concrete and steel under-girding and the bottom of the bridge. Possibly 100 such nests were present at the time of our visit; stains on the concrete at points of attachment attested to the former presence of many more. At the time of visit the nests were unoccupied by cliff swallows; the first vanguard of migrating swallows was just arriving from the south and nest building had not yet begun.

Attention was drawn to the apparently empty nests by the squeaking of bats and the musty odor of *Tadarida*, which was apparent at some distance from the nests. A shot from the auxiliary into one nest brought down 15 bats; 10 more bats were shot as they emerged from the broken mud structure. The liquid capacity of this nest was estimated at about 1½ pints. The 25 bats from this nest proved to consist of 20 *Tadarida* and 5 *Myotis*, all males. Subsequent collecting yielded 17 more bats from four additional nests: 11 *Tadarida* and 6 *Myotis*, all males, with the exception of one female *Myotis*. The solitary female was taken from a nest containing both male *Myotis* and male *Tadarida*; she was without young and subsequent dissection proved her to be not pregnant. All nests from which specimens were collected contained both *Tadarida* and *Myotis* communially, with the exception of one nest which contained only two *Myotis*. Half of the ten nests examined contained no bats.

Average (mean) length and extreme measurements, in millimeters, for the specimens collected are: *T. b. mexicana* (29 specimens), males—total length 92.1 (84–102), tail vertebrae 34.7 (30–39), hind foot 10.8 (10–12), forearm 44.0 (41–47), ear from notch 15.9 (13.5–17), tragus 4.0 (4–5); *M. v. incautus* (10 specimens), males—total length 88.2 (83–94), tail

vertebrae 37.9 (30–42), hind foot 10.7 (8.5–12), forearm 43.3 (40–46), ear from notch 13.3 (11–16), tragus 7.5 (6–9); *M. v. incautus* (1 specimen), female—total length 88, tail vertebrae 39, hind foot 11.5, forearm 44, ear from notch 13, tragus 7. All specimens were judged to be adult based on size, ossification of skeletal parts, and development of reproductive organs. Testes were not enlarged in males.

Although many other bridges were examined in Kinney and Val Verde counties, Texas, no other bats were found in cliff swallow nests. Bridge construction apparently influences the survival of old cliff swallow nests in which bats might roost: most bridges in the area did not possess "cross-hatched" under-girding, and spring floods had removed all swallow nests from under such structures. The "cross-hatched" under-girding apparently makes an effective air seal against water rising above the bottoms of the girders and into corners where cliff swallow nests are constructed. The occupancy by bats of swallow nests in the area at the time of visit may have been influenced by a series of "northers," or cold air masses moving in from the northwest, which had passed through the region on alternating days during the previous week. The swift and unseasonal appearance of these "northers" may have forced the bats to occupy an unusual but convenient roosting place.—O. Marcus Buchanan, *Dallas Museum of Natural History, Dallas, Texas. Received July 22, 1957.*

RETURNS OF MEXICAN FREETAIL BATS BANDED IN OKLAHOMA

There has been considerable speculation in the past concerning the nature of population movements of the Mexican freetail bat, *Tadarida brasiliensis mexicana*. Some have contended that seasonal movements are purely local, while others have insisted that the activity is of a truly migratory nature. To date the only positive evidence supporting the latter view has been the recovery of a single band which was placed on a bat by Richard G. Prasil at Carlsbad, New Mexico, and was recovered in Jalisco, Mexico, approximately 800 miles to the south (Villa and Malaga-Alba, Some notes on the distribution of North American bats, etc.; read before the American Society of Mammalogists, June 16, 1956).

In the State of Oklahoma there are five known cave-dwelling colonies of freetail bats. The species formerly also occupied the Alabaster Cavern, but has abandoned it except for brief periods in spring and fall since it has been illuminated and opened to the public. The cavern is used by them throughout the summer as a night roost, however.

The bats first appear in the caves of northern Oklahoma during the early part of April. During the ensuing weeks the numbers increase perceptibly, especially prior to the first week of May, by which time they are present in great numbers. The young are born during late June and July, and the colonies reach their maximum size in August and September when the young are flying with the adults. During the latter part of October the bats disappear and are not to be seen again until the following spring.

The writer has been observing a number of these colonies for the past several years, and during the last four approximately 10,000 freetails have been banded in the hope that recoveries might reveal their winter destination. Numerous local band recoveries have been made, usually from the same cave where the band was applied. These are of interest only in that they indicate a certain degree of colony integrity from year to year. That this integrity is not complete is indicated by two recoveries. One reported by Jack Twente from Merrihew Cave in October of 1952 was of a band placed on a bat from Selman's Cave on May 26 of the same year. The band was found in the regurgitated pellet of an owl. The caves in question are only approximately 20 miles apart. The other recovery was made when a random sampling of bats was made in Reed Cave in Greer County, on May 4, 1956. The band had been placed on the bat at Vickery Cave in October, 1955. The two caves are approximately 115 miles apart. (Fig. 1.)

In addition to local recoveries, two have been made that indicate true long-range migration. On November 18, 1954, Dr. Richard B. Eads of the Texas State Department of Health

secured a small sample of freetail bats from Bracken Cave in the outskirts of San Antonio, Texas. Among those killed was one bearing a band which we had placed on the bat on October 9 of the same year at Vickery Cave. This recovery represents a movement of some 500 miles in a period of no more than six weeks. On about April 1, 1956, a bat was caught in a store in Elgin, Texas, bearing a band that had been applied on July 14, 1955, in Selman's cave when the bat was a baby. This distance in this case is approximately 450 miles.

Dr. Eads has informed me that the bats inhabiting the nine known brood colonies in the Edwards Plateau region of Texas exhibit the same behavior as that described above for the Oklahoma population, except that the period of winter absence is shorter. Bats disappear from the Texas caves near the end of November, and reappear during March.

These data indicate that the cave-dwelling population of *T. brasiliensis mexicana* of Texas and Oklahoma executes a southward migration over a period of some two months during the late fall to some undetermined destination south of the Edwards Plateau. It is hoped that

FIG. 1.—Map showing locations of the five known nursery-colonies of *Tadarida brasiliensis mexicana* in Oklahoma, and two localities in Texas where bands have been recovered.

continued banding will reveal more of the nature of this migration and disclose the wintering-ground of the subspecies.

This is contribution No. 255, Zoology Department, Oklahoma State University. The writer wishes to acknowledge the generous help of the National Institutes of Health in financing the research of which this report is a part.—BRYAN P. GLASS, *Dept. of Zoology, Oklahoma State Univ., Stillwater. Received May 4, 1957.*

REMARKS ON EXTERNAL FEATURES OF *TADARIDA FEMOROSACCA*

The pocketed freetail bat, *Tadarida femorosacca* (Merriam), is commonly described as similar to the Mexican freetail bat, *Tadarida brasiliensis mexicana* (Saussure), but larger. In fact, except for uncommonly recorded phalangeal and cranial measurements (Shamel, Proc. U.S. Nat. Mus., 78 (19): 1–27, 1931), the measurements of the two species overlap, providing no great help in field identification. Otherwise experienced mammalogists have confided that the "pocket," formed by the fold of membrane from femur to tibia, is obscure to them, and they believe the same characteristic may be seen in *brasiliensis*. Indeed, misidentifications and erroneous reports have resulted. This character is certainly pronounced in the *macrotis* group, and it is not to be disputed here. The main point is that identifications are being missed, an unfortunate circumstance when one considers the current banding programs in the Southwest. It is felt that greater emphasis should be placed on the more obvious external characteristic of the *macrotis* group, the vertical septum by which the ears are attached medially (Plate I). The ears are separate in *brasiliensis*, in which the septum is absent. *Tadarida molossa* (Pallas) also possesses the septum by which its ears are joined, but it is strikingly larger than *femorosacca*.—DENNY G. CONSTANTINE, *Communicable Disease Center, U.S. Public Health Service, Carlsbad, New Mexico. Received March 5, 1957.*

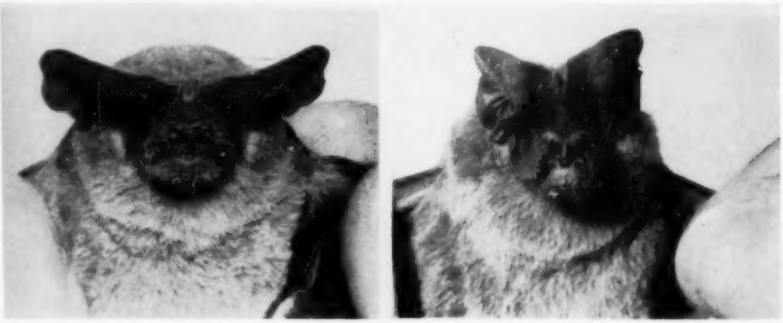

PLATE I

Left, *Tadarida brasiliensis mexicana*; right, *Tadarida femorosacca*. Photos by Tex Helm.

POLYDACTYLY IN THE EASTERN PIPISTREL

A young female *Pipistrellus s. subflavus* taken from Old Indian Cave, Jackson County, Florida, on February 3, 1956, exhibits polydactyly, having six digits on both the fore and hind limbs. This bat, No. 3601 in the Florida State Board of Health collection, was taken with 67 normal individuals while hibernating in the main bat chamber of the cavern. This is

the only one of 306 pipistrels and 4,364 bats of other species examined in which this condition was found.

Two thumbs are present on both forelimbs. In both cases the extra thumb appears to be the medial one, its claw showing a similar degree of wear to that of the other. Clearing and staining with alizarin shows that the thumbs of each pair have two separate phalanges but share a fused metacarpal. Similarly, the tendon of the extensor muscle of the pollux bifurcates at the level of the metacarpal. The six toes on the left foot are identical in structure, although the fifth toe is slightly shorter than its neighbors and is fused with the sixth digit at its base. On the right foot the sixth toe is approximately half as long as the others. It lacks one phalanx but has a perfect claw. The fourth and fifth toes are slightly fused at their bases. All eleven fully developed toes appear to be functional. A similar condition has been reported in *Tadarida mexicana* by Koford and Krutzsch (Jour. Mamm., 29: 418, 1948).—William L. Jennings, *Dept. of Biology, Univ. of Florida, Gainesville, and The Florida State Board of Health, Jacksonville.* *Received July 19, 1957.*

HOARY BAT THE VICTIM OF A BARBED WIRE FENCE

The barbed wire fence is occasionally a fatal obstacle to flying mammals. In May, 1933, Paul B. Johnson (Jour. Mamm., 14: 156) reported finding a mummified red bat (*Lasiurus borealis*) hanging from a barbed wire fence. A similar accident was reported for a flying squirrel by James S. Findley in 1945 (Jour. Mamm., 26: 437).

On July 28, 1956, a hoary bat (*Lasiurus cinereus*) was found by the author hanging from the top wire of a fence in the University of Wisconsin Arboretum. The individual was securely attached to a slanted barb hooked into the right side of the uropatagium. The bat, either in its sudden stop or in its struggle to escape, looped itself around the wire causing a triple puncture in the interfemoral membrane.—Frank A. Iwen, *Zoology Dept. Museum, Univ. of Wisconsin, Madison.* *Received July 3, 1957.*

ANOTHER INSTANCE OF BAT *VERSUS* ANT

When investigating a colony of *Eptesicus fuscus* on July 9, 1957, at Battle Ground, Tippecanoe Co., Indiana, the author noticed a subadult male with the head of an insect attached to its upper left lip, below and just anterior to the eye. Upon removal and closer examination the insect head was identified as belonging to a winged queen of *Camponotus pennsylvanicus* (DeGeer), a large ant of a subgenus whose members are commonly known as carpenter ants. There was no apparent infection and only minor swelling where the insect was fastened.

Handley (Jour. Mamm., 37: 279, 1956) reported a similar instance of the head of an ant, *Camponotus* sp., attached to the face of *Eptesicus fuscus fuscus*. As in his case, the head of this ant was firmly attached and only removed with some of the bat's skin.

Thanks is extended to Dr. Leland Chandler, Curator of Insects at Purdue University, for kindly verifying the identification of the insect.—Nixon Wilson, *Dept. of Entomology, Purdue Univ., Lafayette, Indiana.* *Received July 27, 1957.*

EARLY BREEDING IN THE RIVER OTTER

In my experience with river otters, *Lutra canadensis*, in northern Minnesota, I have never known females to breed before they were two-year-olds, first couching their cubs at three years after a variable gestation period. In my previous notes (Jour. Mamm., 32: 1–9, 1951) were listed the breeding records of four captive female otters, none younger than four years of age, and with reference to boar otters the statement was made that "An otter is not sexually mature until two years old."

But recently one of my two-year-olds gave birth to cubs. Shadow, who was born on December 30, 1954, mated as a yearling with a four-year-old male, Blackhawk, on April 6, 8 and 10, 1956. She couched quadruplets (three males and one female) on January 24, 1957. This represents a gestation period of 9 months and 18 days as calculated from her first recorded mating, the same length of time as previously reported for Tara in 1948. Incidentally Sunshine, Shadow's twin sister, first bred on March 12, 1957, with the same Blackhawk; this was the usual case of a two-year-old first mating.—EMIL E. LIERS, *Homer (Winona County), Minnesota. Received May 13, 1957.*

ODD ITEMS IN BOBCAT STOMACHS

These brief remarks on stomach contents of wild bobcats, *Lynx rufus*, are occasioned by my recent unearthing of eight poorly preserved specimens, each a stomach and small intestine, cryptically tagged "Cat Stomachs." Two of them were further labeled, "Wild Cat—shot ahead of dogs in Montmorency County, Mich. Dec. 12, 1932. Reported to be eating snowshoe hares." Measurements of the animals were appended. No data accompanied the others, but it seems probable that all eight represent approximately the same locality and date.

Three of the specimens were practically empty (moist contents less than 10 cc.); contents of one measured 160 cc., of another 358 cc., and of the remaining three from 55 to 75 cc. The contents of all were, for the most part, unrecognizable. However, one stomach and one intestine contained tightly packed masses of the nematode *Physaloptera praeputialis*?, kindly identified by William D. Lindquist. This genus has previously been reported by Hamilton and Hunter (Jour. Wildl. Mgt., 3: 99–103, 1939) as common in Vermont bobcats.

In three of the stomachs were several or many porcupine quills; in only one case was a quill embedded in the stomach wall. Fur of snowshoe hares was also present in two of these three stomachs. A number of investigators have reported bobcats feeding on porcupines. For example, Hamilton and Hunter (*op. cit.*) found remains of porcupine in 8.6 per cent of 143 bobcat stomachs, and observed that it "appears to be an important food species of the bobcat." The large percentage of nearly empty digestive tracts in my sample suggests that other prey may have been scarce at the time the bobcats were collected. It seems likely that porcupines were being used as emergency rations.—RICHARD H. MANVILLE, *151 Ossining Road, Pleasantville, New York. Received July 16, 1957.*

A MANITOBA RECORD OF THE GRAY FOX

R. M. Anderson (Nat. Mus. of Canada, Bull. 102: 50, 1946) gives one Canadian record of the Wisconsin gray fox, *Urocyon cinereoargenteus ocythous*, taken in the Rainy River district of extreme southwestern Ontario. Anderson states, "The grey fox is known to be extending its range northward in both east and west, coincident with the continuing northward spread of the cottontail rabbit (*Sylvilagus* spp.), and should be looked for in southern Manitoba."

Another, and rather startling, occurrence of the same subspecies is recorded for Lake Athabasca, Alberta, by Moore (Jour. Mamm., 33: 253, 1952).

Other records, though not from Canada, are those presented by Viola S. Schantz (Jour. Mamm., 31: 197–198, 1950) from Wilton, North Dakota, and from Minot, North Dakota, respectively 120 and 60 miles south of the international boundary. These, together with the Rainy River specimen, have indicated (as Anderson points out) that the gray fox might be expected in Manitoba. We now have that record.

On January 12, 1957, Mr. Marcel Bouchard of St. Adolphe, Manitoba, trapped an animal which, on being submitted to the fur buyers, was rejected as "an American fox." Mr. Bouchard then took the pelt to J. P. Hawkins, taxidermist, who recognized it and immediately

notified the Manitoba Museum. Through the courtesy of Mr. Bouchard we now have the pelt and skull of the animal. It is an old male. Subspecific determination was made through the courtesy of Dr. Austin W. Cameron, National Museum of Canada, and Dr. Charles P. Lyman, Museum of Comparative Zoology, Harvard University.

St. Adolphe is some 20 miles south of Winnipeg. If we exclude the Lake Athabasca specimen (800 miles north of normal range) as an abnormal occurrence, the Manitoba specimen extends the known northward range of the Wisconsin gray fox by about 80 miles.

A careful check with local fur buyers reveals but one other probable occurrence in Manitoba. Mr. A. Suchrov, buyer for S. I. Robinson Company, recalls handling a single pelt taken at Sprague (southeastern Manitoba) in 1946 or 1947.—RICHARD W. SUTTON, *Manitoba Museum, Winnipeg, Manitoba.* *Received July 1, 1957.*

GOOSEBEAK WHALE FROM NORTH CAROLINA

The goosebeak whale, *Ziphius cavirostris* Cuvier, is of world-wide distribution but there are few records of its occurrence along the eastern coast of North America. In his summary of records of this whale from the Atlantic Coast of North America, Ulmer (Proc. Acad. Nat. Sci. Phil., 93: 107–122, 1941) listed one specimen from each of the following states: South Carolina, New Jersey, Georgia, Rhode Island and New York. One specimen was recorded from Virginia by Handley and Patton (Wild mammals of Virginia, 1947) and five have been recorded from Florida (Moore, Amer. Midl. Nat., 49: 117–158, 1953; Wood and Moore, Evergl. Nat. Hist., 2: 136–142, 1954).

In October, 1954, the rostrum of a beaked whale was found near Fort Fisher, New Hanover County, North Carolina. It was discovered in a consolidated shell bed from which the sand had been removed a few days previously by a hurricane. The rostrum was delivered to the North Carolina State Museum and was later identified as a specimen of *Ziphius cavirostris* of Quaternary Age by Dr. Remington Kellogg, Director of the U.S. National Museum.—STURGIS MCKEEVER, *North Carolina State Museum, Raleigh. (Present address: 319 Camellia Drive, Camilla, Georgia.)* *Received July 3, 1957.*

THE COMMON BLACKFISH IN VIRGINIA COASTAL WATERS

Early in May, 1956, a single blackfish came ashore on the outer beach at Fishing Point, Assateague Island, Accomack County, Virginia. It is not known whether the whale was alive or dead when it stranded. As shown by colored photographs taken at the time, the whale was in good condition when it was discovered by Mr. Jacob Valentine, Manager of the Chincoteague National Wildlife Refuge. On May 15, with the assistance of Mr. Valentine, the animal was photographed, measured, and the skull secured for the U.S. National Museum. This specimen has been identified as *Globicephala melaena* Traill, and it proves to be the first valid record of the species from Virginia waters.

Although current literature gives the range of *G. melaena* as extending south in the western Atlantic to the coast of Virginia, the coast of New Jersey has until now been the southernmost valid locality. Dr. Charles O. Handley, Jr., U.S. National Museum, has pointed out to me that all specimens from Virginia, recorded as *G. melaena* by Handley and Patton (*Wild Mammals of Virginia*, p. 204, 1947) actually are *G. macrorhyncha*. The specimen reported in this paper, however, proves that the range of *G. melaena* does extend as far south as Virginia.

External measurements of this specimen (U.S. Nat. Mus., No. 303018) are: tip of snout to median notch of flukes, 199; tip of snout to corner of mouth, 16; tip of snout to anterior base of dorsal fin, 60; greatest height of dorsal fin, 16; length of pectoral fin along anterior edge, 54; greatest breadth of pectoral fin, 12; breadth across flukes, from tip to tip, 48 in.

Cranial measurements, as defined by True (Bull. U.S. Nat. Mus., No. 36, p. 12, 1889), are as follows: total length of skull, 650; length of rostrum, 325; breadth of rostrum at base of maxillary notches, 262; breadth of rostrum at its middle, 210; breadth of premaxillaries at

middle of rostrum, 174; greatest breadth between outer margins of premaxillaries proximally, 176; extremity of rostrum to anterior margin of superior nares, 441; extremity of rostrum to end of crest of pterygoids, 449; breadth between orbits, 439; breadth between hinder margins of temporal fossae, 294; length of mandible, 525; length of symphysis of mandible, 66; length of tooth row of mandible (posterior border of last socket to anterior edge of foremost socket), 145 mm.

Two species of the genus occur on the Atlantic coast of North America, *Globicephala melaena* Traill, and *Globicephala macrorhyncha* Gray. *G. melaena* (known range in Western Atlantic: coast of Iceland and Greenland south to Virginia) is much like *G. macrorhyncha* (known range in Western Atlantic: Gulf of Mexico and West Indies north to southern New Jersey) in size and general appearance. However, according to True (*loc. cit.*) the pectoral fin is proportionately longer in *G. melaena* than in *G. macrorhyncha*. *G. melaena* is also supposed to have a white area in the region of the throat which is not present in *G. macrorhyncha*. Photographs of the specimen here reported show clearly defined whitish areas on the throat and in the anal region. The remainder of the body was uniformly black.

Despite great individual variation in most cranial features, certain characteristics serve to distinguish between *G. melaena* and *G. macrorhyncha*. The premaxillary bones in the latter flare laterally and completely overlie the dorsal surfaces of the maxillary bones for about the anterior half of the rostrum. In *G. melaena*, the premaxillaries do not expand so greatly and do not completely overlie the maxillaries except near the tip of the rostrum.

In dorsal aspect, the outer margins of the maxillary bones of adult *G. macrorhyncha* are approximately parallel in the basal third of the rostrum and anteriorly converge rather sharply to the tip. In *G. melaena*, on the other hand, the outer margins of the maxillaries converge gradually from the base of the rostrum to the tip. This imparts to the beak of *G. melaena* a slender appearance, which is enhanced by the comparative narrowness of the premaxillaries.

The two species differ also in the extent of the parietal within the temporal fossa. The area of this bone is small in *G. macrorhyncha*, owing to the encroachment of the frontal and alisphenoid into the fossa. In *G. melaena*, the frontal barely enters the temporal fossa and the parietal is correspondingly broader.

The teeth in the present specimen, all very much worn, number 7/8–7/7. They were not rigidly attached to the jaws in the fresh animal, and could be moved around as if they were imbedded only in the gum. The boundaries of the alveoli in the cleaned skull are difficult to determine, particularly in the upper jaws, where there appear to be nine on both sides. Ten clearly defined sockets are present in each mandible. According to True, the avergae number of teeth in *G. melaena* is 9/9 to 10/10, and in *G. macrorhyncha* 8/8. There appears to be, however, great individual variation in both species. One specimen of *G. melaena* in the U.S. National Museum, taken off the coast of Massachusetts, has only eight alveoli in each mandible. Another example of this species has eleven teeth in the right side of the upper jaw. Specimens of *G. macrorhyncha* show a variation in number of mandibular alveoli from seven to ten on each side, and in the maxillae from seven to eight.—John L. Paradiso, *U.S. National Museum, Washington 25, D.C.* *Received July 5, 1957.*

FOOD OF PORPOISES IN WATERS OFF JAPAN

Relatively little information on the food of the smaller cetaceans has appeared in the literature. This is true for most species because scientists usually lack the opportunity and the techniques for taking more than an occasional cetacean. When advantage can be taken of some commercial operation, specimens often become available in large enough numbers to provide important information. The skilled marine mammal hunters of the northern prefectures of Japan, for example, may take thousands of porpoises and dolphins annually.

Porpoises and dolphins are widely distributed and in total comprise a very large population. It is, therefore, of interest to know how they fit into the ecology of their marine habitat and

also what economic influence, if any, they may have. Generally, few accusations of damage have been leveled at the small cetaceans. This is at least partly true because fishermen know very little about the animals and have no reason to suspect them of competition.

In the course of a cooperative investigation of fur seals (*Callorhinus ursinus*) by representatives of Canada, Japan and the United States in 1952, porpoises were collected when it was possible to do so without interfering with the main object of the investigation. Since the chartered harpoon vessels were manned by experienced and enthusiastic porpoise hunters, the killing and recovery of these animals was accomplished in an amazingly efficient manner.

One hundred sixty-one stomachs of the True porpoise (*Phocoenoides truei*) and seven stomachs of the Dall porpoise (*Phocoenoides dalli*) were collected. Credit for collecting and preserving the specimens is due to the following: F. M. Taylor and B. M. Chatwin of Canada; Seiji Ichinotani, Fukuzo Nagasaki, Masayuki Nakajima, Seiji Suzuki and Shiro Yoshizaki of Japan; Karl W. Kenyon and A. J. Nicholson of the United States. Giles W. Mead and Takiharu Abe made the stomach examinations.

Table 1 shows the stomach contents by volume percentage, frequency, and frequency percentage.

Scheffer (Murrelet, 34: 27–30, 1953) reported that the stomach contents of six *Phocoenoides dalli* taken from Monterey, California to latitude 45° 44′ N. off the Oregon coast contained hake (*Merluccius productus*), squids (*Loligo opalescens* and unidentified species), horse mackerel (*Trachurus symmetricus*) and unidentified fish. Two Dall porpoises from the Gulf of Alaska had fed only on capelin (*Mallotus villosus*).

Lantern fish (*Myctophidae*), squids (*Watasenia, Ommastrephes* and unidentified species), fish of the family Sudidae, and a hake-like fish (*Laemonema morosum*) were reported (Wilke, Taniwaki and Kuroda, Jour. Mamm., 34: 488–497, 1953) to compose the stomach contents of 24 True and 4 Dall porpoises taken along the North Pacific coast of Japan in 1949 and 1950. The marked difference in food between the porpoises from North America and

TABLE 1.—*Stomach contents of 86[1] True porpoises and 7 Dall porpoises collected in waters off Japan, March to June, 1952*

FOOD ITEM	TRUE PORPOISE			DALL PORPOISE		
	Percentage by volume	Frequency	Frequency[2] percentage	Percentage by volume	Frequency	Frequency[2] percentage
Squids:						
Ommastrephes sloani pacificus	5	22	26	2	1	14
Watasenia scintillans	6	35	40	3	3	43
Unidentified squids	tr.	5	6	tr.	2	29
Fishes:						
Sudidae: *Paralepis sp.*	4	7	14	10	2	29
Lantern fish						
Notoscopelus sp.	21	27	31	37	2	29
Diaphus sp.	2	6	7	—	—	—
Tarletonbeania taylori	1	5	6	11	3	43
Lampanyctus sp.	tr.	1	1	—	—	—
Myctophum sp.	tr.	2	2	2	2	29
Unidentified Myctophidae	49	44	51	35	3	43
Gadid, *Laemonema longipes*	11	5	6	—	—	—
Mackerel, *Scomber japonicus*	1	2	2	—	—	—

[1] 75 additional stomachs were empty.
[2] Percentage of stomachs with food containing item.

those from Japan is almost certainly a result of the different type of oceanic area in which they were taken. The North American specimens came from relatively shallow water, mostly 100 fathoms or less in depth. Japanese specimens were from waters up to 1,500 fathoms in depth where only pelagic forms are available to the porpoises.

A rather remarkable consistency in food species and proportions is shown by the 1949–1950 and 1952 collections from waters off Japan. Squids accounted for 11 per cent of the food volume of *P. truei* in the earlier collection and 11 per cent in 1952. Various members of the *Myctophidae* (lantern fishes) composed 70 and 73 per cent of the stomach contents in the earlier and later years, respectively. The rather rare fishes of the family Sudidae made up 3 per cent of one collection and 4 per cent of another and a gadid (*Laemonema*) varied only from 11 to 12 per cent. Mackerel (*Scomber japonicus*), which occurred once, was the only new species found in 1952.

Because of this consistency it seems safe to conclude that for the areas and season represented the samples depict accurately the important food species of *Phocoenoides*. Other species will be occasionally taken as shown by the appearance of mackerel. The squid *Ommastrephes* and the single occurrence of mackerel are the only commercially important species found in the stomach contents and hence noteworthy damage to commercial fisheries through predation by *Phocoenoides* spp. seems unlikely.

The pelagic lantern fishes which provide a large part of the food of porpoises are of no commercial concern. Some are little known. For example, the first known specimen of *Tarletonbeania taylori* was recovered by the writers in 1952 from *Phocoenoides truei* (Mead, Zoologica, 38:105–108, 1953).—Ford Wilke and A. J. Nicholson, *U.S. Fish and Wildlife Service.* *Received June 24, 1957.*

WINTER ACTIVITY OF RED SQUIRRELS IN INTERIOR ALASKA

The mammals that inhabit the subarctic spruce forest or taiga may be classified into two groups on the basis of their winter activity—those that live above the snow and are therefore subjected to the vicissitudes of weather, and those that live or retreat beneath the snow in a warmer and more stable environment (see Pruitt; Arctic, 10: 131–138, 1957). Those that weigh upwards of 200–250 grams usually live above the snow—hare, lynx, fox, wolf, moose, caribou. Those that weigh less than about 200 grams usually live or retreat beneath the snow—weasels, voles, shrews (Formosov, Materials for Fauna and Flora USSR, Moscow (N.S.), Zoology 5: 152 pp., 1946). The red squirrel (*Tamiasciurus hudsonicus*) is just on the borderline between these two groups. Moreover, the red squirrel is one of the most obvious mammals in the taiga. It is one of the mammals adapted to the taiga and may be considered characteristic of it. There are, however, conflicting reports in the literature regarding its winter activity. Dice (Jour. Mamm., 2: 20–28, 1921) stated that it was seldom noted when the air temperature fell below –30°F. in interior Alaska, while Murie (Jour. Mamm., 8: 37–40, 1927) implied that it was active all winter long.

For the past three years we have made visits almost daily to a study area in mature white spruce (*Picea glauca*) forest near Fairbanks. For a more complete description of this area as well as for the environmental analysis see Pruitt (*op. cit.*). In addition to microclimate observations, records have been kept of all animal activity noted. For the purposes of this discussion we have included only those observations made when a complete snow cover was present, from about October 10 to April 30.

Figure 1 shows the relationship between observed activity of the squirrels on the plot and the ambient air temperature at the time the observations were made. We could find no relation between squirrel activity and barometric pressure, wind or clouds. In 1954–55 the squirrels appeared to respond to the lengthening hours of daylight by a corresponding increase in activity. This increase in activity was not repeated in 1955–56 or 1956–57, however.

In the subarctic taiga red squirrels become subterranean and subnivean animals in winter. Extensive burrow systems are constructed under and through the kitchen midden. It is evident from Fig. 1 that squirrels are virtually never active above the snow surface when the ambient air temperature is below –25°F. and may or may not be active when the ambient air temperature is above that. We also noted that squirrels were virtually never active when the difference between the temperatures of the air and the moss surface was greater than 20°F. or when the difference between the temperatures of the air and moss at 9 inches below the surface was greater than 30°F. Therefore the environmental conditions experienced by the red squirrels in winter are not those of the macroclimate but resemble more closely those experiencd by *Sorex* and *Clethrionomys*.

This report is a contribution from a larger study of the bioclimates of taiga mammals which was supported by contract with the U.S. Air Force, Office of Scientific Research of the Air Research and Development Command.—William O. Pruitt, Jr., *Dept. of Physiology, School of Medicine, Univ. of Pennsylvania* and Charles V. Lucier, *Arctic Aeromedical Laboratory, Ladd A.F.B., Alaska.* (*Authors' current address*: *Box 282, College, Alaska.*) *Received May 15, 1957.*

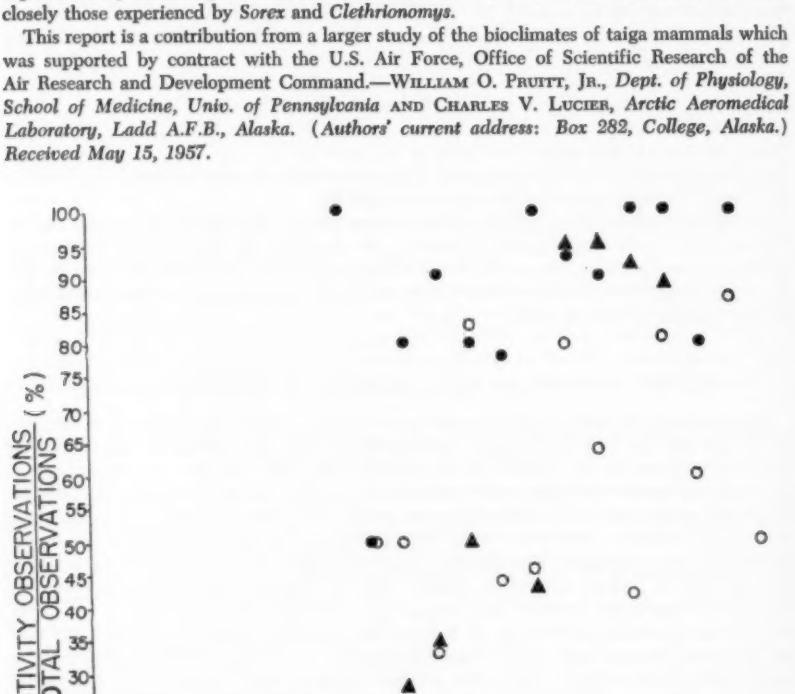

Fig. 1.—Observed activity of red squirrels in relation to air temperature. Closed circles indicate winter, 1954–55; closed triangles, winter, 1955–56; open circles, winter, 1956–57.

MELANISTIC RED SQUIRRELS FROM CAYUGA COUNTY, NEW YORK

Melanism is apparently rare in the red squirrel, *Tamiasciurus hudsonicus*. Layne (Ecol. Monogr., 24: 232, 1954,) found no melanistic individuals in 575 specimens from New York, and reported only two references to such individuals in the literature.

In February, 1957, Ellis Hall of Victory, Cayuga County, New York, shot three melanistic red squirrels at his home. Two of these specimens are now in my possession. A fourth melanistic individual was seen at the same time. The two specimens are in typical winter pelage, except for the difference in color. The tail is almost completely black except for reddish tips on some of the hairs. The ears and face are also black, with red-tipped hairs on the face, and the usual black stripe down each side, which is often lacking in the winter pelage of normally pigmented individuals, is very prominent. The sides are grizzled in appearance, with individual hairs having alternate bands of black and reddish gray, and many of the guard hairs are solid black. The usual red band down the middle of the back is present in these specimens, but the red is largely masked by black guard hairs and by extensive black banding on the reddish hairs of the underfur. The abnormal coloring is restricted to guard hairs and to the outer ends of the underfur, the base of the underfur being the same dull gray as that on a normally colored squirrel in similar pelage. The ventral surface is essentially similar to that of a normally colored red squirrel, though some black guard hairs occur and there is a patch of dark fur around the penis of the male, and a tiny patch of black fur on the chin of each specimen.

These two individuals are probably young of the previous year, judging by weight, measurements and condition of the reproductive structures. It seems likely that the four melanistic individuals were siblings from a single litter, since none had been seen in the vicinity prior to this winter.—ALLEN H. BENTON, *N.Y.S. College for Teachers, Albany, New York.* *Received May 29, 1957.*

THE BACULUM IN THE POCKET GOPHER

Apparently the baculum (*os priapi*) has been recorded in no more than five orders of mammals: Chiroptera, Carnivora, Insectivora, Primates and Rodentia. The baculum has been useful in taxonomic evaluation of certain groups of rodents and as an age criterion in mink, otter and beaver. It is the purpose of this note to describe the baculum in two species of the genus *Geomys*. This structure apparently has not been heretofore described for the family *Geomyidae*.

Figure 1 depicts the bacula of two species of pocket gophers occurring in southern Texas, *Geomys personatus fallax* and *G. bursarius attwateri*. The bacula of these pocket gophers, though less recurved ventrally, conform to the simple, entire structural plan exemplified in the *Heteromyidae* (Burt, Jour. Mamm., 17: 145–156, 1936). This non-digitate structural plan appears to typify the superfamily *Geomyoidea*. As in other closely related species of rodents (Blair, Jour. Mamm., 23: 196–204, 1942) the bacula of *personatus* and *bursarius* are of similar shape and appearance. Certain differences, however, seem to be consistent. The baculum of *bursarius* has a proportionately and on the averge an actually wider base relative to length than does the baculum of *personatus*. Average length of 12 bacula of adult *personatus* specimens was 10.17 mm. and average width of the base was 1.59 mm. In this series the length of the *personatus* bacula averaged 6.39 times the basal width and the average body length in this species (191.59 mm.) was 19.8 times the average length of baculum. The average length of nine adult *bursarius* bacula was 9.86 mm. with an average basal width of 1.70 mm. The length of the baculum averaged 5.80 times the basal width. Average body length in *bursarius* (167.50 mm.) was 16.9 times the average length of baculum. The middle portion of the shaft of the baculum seems generally more massive in *personatus* than in *bursarius*. A few bacula of immature specimens of both species were examined. Figure

1 represents the baculum of an immature *personatus*. The tip of the baculum is markedly dorsoventrally decurved, much more so than in adult specimens. With attainment of maturity the baculum becomes more rugose and massive throughout and the tip is only slightly decurved. It is possible that this structure may furnish another taxonomic criterion useful in analysis of the very complex speciation problems typical of this family.—Thomas E. Kennerly, Jr., *Dept. of Biology, Baylor Univ., Waco, Texas.* *Received July 10, 1957.*

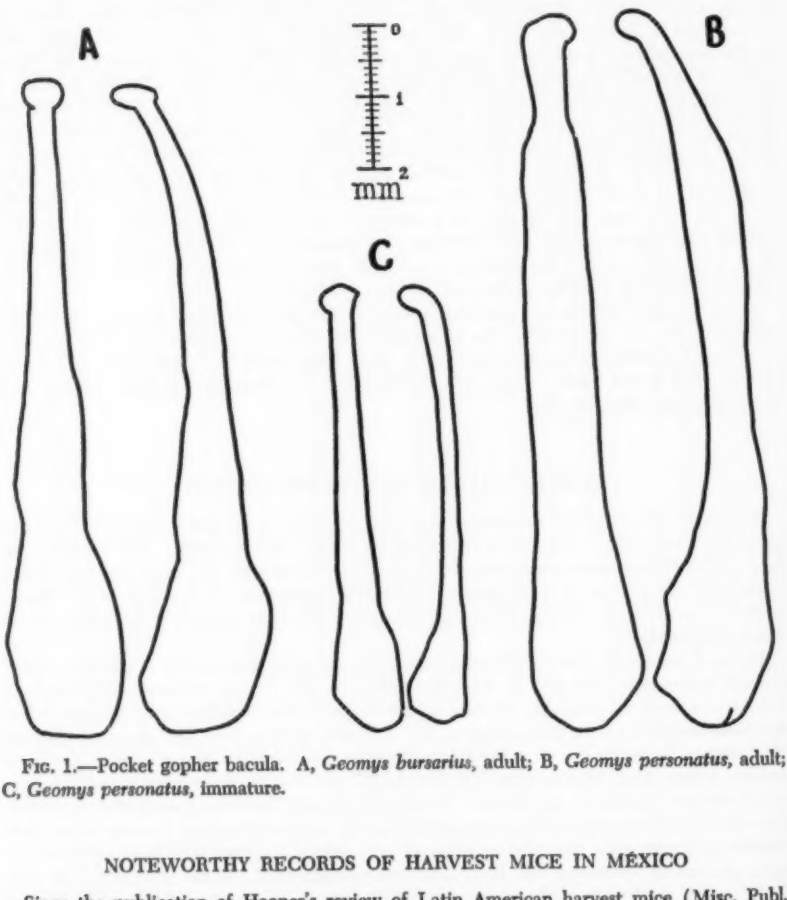

Fig. 1.—Pocket gopher bacula. A, *Geomys bursarius*, adult; B, *Geomys personatus*, adult; C, *Geomys personatus*, immature.

NOTEWORTHY RECORDS OF HARVEST MICE IN MÉXICO

Since the publication of Hooper's review of Latin American harvest mice (Misc. Publ. Mus. Zool., Univ. Mich., 77: 1–255, 1952) collectors from the Museum of Natural History, University of Kansas, have obtained specimens of *Reithrodontomys mexicanus mexicanus* and of two subspecies of *Reithrodontomys microdon* from México that add to our knowledge of the distribution of these mice. Financial assistance from the National Science Foundation and the Kansas University Endowment Association made the collection of these specimens possible.

Reithrodontomys mexicanus mexicanus (Saussure).—Only two specimens of this subspecies have been reported from Tamaulipas, both from Rancho del Cielo, 5 mi. NW Gómez Farías (Hooper, *op. cit.*: 144; Goodwin, Amer. Mus. Novit., 1689: 11, 1954). On March 1, 1954, William Schaldach obtained a third specimen, a subadult male (KU 60333), at Rancho Pano Ayuctle, 6 mi. N Gómez Farías, 300 ft., Tamaulipas. This individual provides the lowest known altitudinal record for the species (Hooper, *op. cit.*: 139, listed Metlaltoyuca, near 1000 ft., Puebla, as the lowest record of occurrence known to him). Schaldach also obtained a series of *Reithrodontomys fulvescens intermedius* at Rancho Pano Ayuctle.

On September 12, 1954, Robert W. Dickerman obtained a subadult male *R. m. mexicanus* (KU 62676) from 2 mi. N Pluma Hidalgo, 4400 ft., Oaxaca. This specimen provides the second locality of occurrence for the species in Oaxaca and extends the known range of the subspecies approximately 94 miles south-southwest from Totontepec, the previously reported locality (Hooper, *op. cit.*: 144).

Reithrodontomys microdon microdon Merriam.—Hooper examined six specimens of this subspecies including only one from the Republic of México (from San Cristobal, Chiapas). Albert A. Alcorn collected two specimens, a subadult female (KU 61719) and an immature male (KU 61726), on July 25 and August 3, 1954, respectively, 4 mi. W Ciudad las Casas (=San Cristobal), Chiapas. External and crainal measurements of KU 61719 are as follows: Total length, 166; length of tail vertebrae, 102; length of hind foot, 19; length of ear from notch, 17; length of skull, 21.7; zygomatic breadth, 11.0; breadth of braincase, 11.2; depth of cranium, 8.7; length of rostrum, 7.8; length of palate, 3.5; length of molar row, 3.3 mm.

Reithrodontomys microdon wagneri Hooper.—Five specimens of this subspecies have been reported, three from 15 mi. SW México City, 9200–10,000 ft., Distrito Federal, and two from 10 mi. NW Ciudad Hidalgo, Cerro San Andrés, 9400 ft., Michoacán, the type locality (*see* Hooper, Proc. Biol. Soc. Wash., 63: 170, 1950). On June 28, 1954, Robert W. Dickerman trapped two adults, a male (KU 62672) and a female (KU 62673), in a mixed forest of pine, oak and beech with an understory of grass and shrubs SE of Sirio on the north slope of Sierra Patamba, 9100 ft., Michoacán. Respective external and cranial measurements of these mice are as follows: Total length, 164, 179; length of tail vertebrae, 93, 100; length of hind foot, 19, 18; length of ear from notch, 18.5, 19; length of skull, 21.4, 22.8; zygomatic breadth, 11.1, 11.7; breadth of braincase, 10.9, 11.3; depth of cranium, 8.4, 8.7; length of rostrum, 7.5, 8.2; length of palate, —, 3.5; length of molar row, 3.2, 3.2 mm. These specimens extend the known range of the subspecies approximately 108 miles westward from the type locality and lend support to Hooper's statement (Misc. Publ. Mus. Zool., Univ. Mich., 77: 168, 1952) that these mice probably occur ". . . elsewhere in the mountains rimming the southern end of the Mexican Plateau."—J. Knox Jones, Jr. and Sydney Anderson, *Museum of Natural History, Univ. of Kansas, Lawrence.* *Received May 10, 1957.*

AN EXTRA MOLAR IN *ERETHIZON*

The occasional occurrence of an extra tooth at the posterior end of the molariform series in certain rodents has been used as evidence for the theory that the tooth which is ordinarily considered as the first molar is, in reality, an unshed premolar (Johnson, Jour. Mamm., 33: 70–72, 1952). This theory has been criticized by Wilson (Jour. Mamm., 37: 295–297, 1956) on several bases, including the fact that such losses of posterior molars are not supported by the fossil record. Which of these arguments is more tenable is open to question at present, but the occurrence of such teeth in fossil and Recent rodents is of interest.

Recently the skull of an adult female porcupine (*Erethizon dorsatum*) which was killed 6 miles south of Kremmling, Grand Co., Colorado, came into the mammal collection at Colorado State University (No. 8366). This specimen has an extra tooth at the posterior end of the upper right molariform row. The extra tooth has a form similar to the others in the row,

but is only about one-half as large as the preceding molar and probably did not extend much above the gum line in life. The normal teeth in the row are not displaced and meet the teeth of the lower jaw in the ordinary manner.

To my knowledge this is the first report of an extra molar in the family Erethizontidae although such teeth have been reported in the Hystricidae by Major (Atti Soc. Italiana Sci. Nat., 15: 111–129, 1872), and in the Echimyidae by Colyer (Variations and diseases of teeth of animals. 750 pp., London, 1936).—R. R. LECHLEITNER, *Dept. of Zoology, Colorado State Univ., Fort Collins. Received July 25, 1957.*

ALBINISM AMONG WILD AFRICAN RODENTS

Occasional albinism is well known to occur among several species of African rodents. I have collected a very few albino specimens in the course of trapping operations near the scientific research center of the I.R.S.A.C. at Lwiro (Bukavu), Belgian Congo. This center is located on the eastern slope of a mountain range extending from SW to NE on the western side of Lake Kivu. The altitude of the trapping sites varies from 1,680 to 2,000 meters. Altogether, from January, 1952, until May, 1957, 142 specimens belonging to the genus *Otomys* Cuvier were caught in that area. Among these, 91 were trapped in the elephant grass and bushes in the immediate vicinity of the laboratories. According to available descriptions, they belong to the group *irroratus* Brants and probably to the species *O. tropicalis* Thomas, showing two grooves, one of them very shallow, on the lower incisors, and seven laminae in the third upper molar.

Among the 91 specimens collected near the laboratory, there was one albino female, completely white with pink eyes. She was caught in September, 1952, by native agricultural workers in fairly thick bushes close to a European garden. She was nursing a young one that was perfectly black, apparently a juvenile coat color. Traps were set repeatedly in the same area, covering some 200 square meters, but only five more individuals of the same species were caught there in over four years. All five were adult and normal in color (dark brown on the back with dark gray or dark brown belly). On the other hand, I have seen, in 1956, the skin of another albino specimen of *Otomys* collected in the northern Kivu District, not far from Lake Edward.

Both the albino female caught at Lwiro and her young died accidentally after six weeks in captivity, while I was away, and the dead specimens could not be preserved. The occurrence of albinism in another African species will be described later in a monograph that I am now preparing.—P. L. PIRLOT, *Institut Pour la Recherche Scientifique en Afrique Centrale, Centre de Lwiro, Bukavu, Belgian Congo. Received July 18, 1957.*

RECORDS OF THE PIKA IN THE TANANA HILLS, ALASKA

The only published record of the pika, *Ochotona collaris*, in the Tanana Hills, Alaska, is from the head of Seward Creek on Glacier Mountain near Eagle, Alaska (Osgood, N. Amer. Fauna 30: 26, 1909; Howell, N. Amer. Fauna 47: 34, 1924). Hall (Univ. Kansas Publ., Mus. Nat. Hist., 5(10): 127, 1951) apparently overlooked this record and gave the "Tanana River" (*sic*) citing Howell (*op. cit.* :36) as the recorded location closest to the Tanana Hills.

Several pikas have been observed along the Steese Highway in the vicinity of Twelve Mile and Eagle Summits by the writer and others. There are four specimens of pika in the University of Alaska collection taken in 1950 from near Mile Post 80 on the Steese Highway (65° 30′ N, 146° W) in the vicinity of Twelve Mile Summit; and one specimen taken in 1953 from near Mile Post 105 on the Steese Highway (65° 30′ N, 145° 30′ W) in the vicinity of Eagle Summit.

During the 1956 field season eleven pikas were collected near the headwaters of the Salcha River (64° 40′ N, 144° 20′ W) and one specimen from the vicinity of the Goodpasture River (64° 25′ N, 144° 55′ W) in the Tanana Hills. Seven additional specimens were taken from near Mile Post 98 on the Steese Highway (65° 27′ N, 145° 32′ W) and two from near Mile Post 107 (65° 30′ N, 145° 20′ W) during the 1957 field season. These specimens have all been incorporated into the University of Alaska collection.

Pikas were not noted at Victoria Mountain (65° 45′ N, 146° 20′ W) by the writer in 1955 and 1956, nor by David Klein (*in litt.*) in 1953 and 1955. They were also absent from Mount Schwatka, further to the west, according to Jack Gross (*viva voca*) in 1956. The range of the pika in the Tanana Hills in Alaska, therefore, extends west and north at least to the Steese Highway, but does not extend west of Beaver Creek which separates Victoria Mountain from the more eastern portion of the Tanana Hills. This is approximately 150 miles to the west and north of previously recorded collections from Glacier Mountain by Osgood (*op. cit.*).

This research was supported in whole or in part by the U.S. Air Force under Contract No. AF(657)-28, monitored by the Alaskan Air Command, Arctic Aeromedical Laboratory, APO 731, Seattle, Washington.—WILBUR L. LIBBY, *Alaska Cooperative Wildlife Research Unit, Univ. of Alaska, College.* *Received June 1, 1957.*

ONCHOCERCA IN AN ALASKAN MOOSE

Species of the genus *Onchocerca* Diesing, 1841, have been reported from numerous ruminants, including cattle, deer, antelope, horses, elk, buffalo, and camels (Yorke and Maplestone, The Nematode Parasites of Vertebrates, 536 pp., 1926). Recently, Rayanyachari and Alwar (India Vet. Jour., 29: 329, 1953) recovered *Onchocerca* sp. from a pig (*Sus scrofa domestica*). The distribution of the parasite group in ruminants is nearly world-wide, having been recorded from Europe, Asia, Africa, and the Americas (Stiles and Hassal, Index Cat. Med. Vet. Zool., 114: 886 pp., 1927).

Numerous female nematodes of *Onchocerca* were collected from flexor tendons and subcutaneous tissues of the hind legs of a moose killed in the Taku River Valley (approximately 15 miles east of Juneau). Few entire adult female specimens were obtained, because of the nodular condition of worms within the tissues, even after employing a pepsin-digestion technique. Since specific identification is based primarily upon certain morphological characteristics of adult males, the Alaskan specimens were tentatively identified as *Onchocerca* sp. However, Mirza (Univ. Aligard, India, *in litt.*), after examining this material, noted a similarity between it and *O. reticulata* Diesing, 1841.

Although Taku River Valley moose migrate into Canada, *Onchocerca* was not reported from this host by Cowan (Rept. Proc. Ann. Game Conv., Canada, 5: 37–64, 1951), nor by Peterson (North American Moose, 200 pp., 1955). *Wehrdickmansia cervipedis* Caballero, 1945 (syn. *O. cervipedis* Wehr and Dikmans, 1935) was listed by Cowan and Peterson. The former investigator described the helminth as having "the thickness of a pencil lead." Such a characteristic does not fit the writers' material, as the threadlike, inconspicuous appearance of the worms within the tissues made them difficult to discern.

Certain members of *Onchocerca* have been incriminated as etiological agents responsible for specific pathological lesions within their respective ruminant hosts. Such lesions varied with the parasite and host involved. Rush (Jour. Mamm., 16: 70–71, 1935) described swollen toes and foot ulcers in deer similar to foot-rot in appearance, which were apparently caused by *O. flexuosa* (Wedl, 1856). The same parasite in antelope, observed as calcified fragments within subcutaneous abcesses, produced a condition which resembled fistulous wither and poll-evil of horses (Dikmans, Jour. Parasit., 19: 246, 1933). *Onchocerca* sp. in a pig caused atheromatous lesions on the endothelial surface of the aorta similar to those seen with *O. armillata* Railliet and Henry, 1909 (cited by Ramanuyachari and Alwar). The patho-

genicity of onchocercids in Taku River Valley moose has not been definitely ascertained. The joints of the infected animal did not appear normal compared with other hosts examined. Gross examination of the articular surfaces by Brandly, Bureau of Animal Industry, Dept. Agriculture (*in litt.*) revealed extensive nonarticular cavities (synovial fossae) which possibly were erosions. However, as pointed out by Brandly, such abundant fossae may be normal for hock joints of some quadrupeds.

Onchocerciasis in moose needs further investigation. Specific threadlike worms are known to produce rodent-ulcers and sore feet in ruminants which make it difficult for these animals to forage for food and consequently make them easier prey (Herman, Calif. Fish and Game, 31: 201–208, 1945).—RALPH B. WILLIAMS, *Alaska Dept. of Health, Juneau, Alaska* AND BERT B. BABERO, *Univ. of Illinois, Urbana.* *Received June 1, 1957.*

DYES SUITABLE FOR USE IN STUDIES OF RAT MOVEMENTS

In movement studies on *Rattus norvegicus* it is a recognized technique to use a dyed bait and to note the distribution of the colored feces that result. Materials employed for this purpose include eosin, gypsum and Chlorazol Sky Blue (Color Index 518) (Chitty and Southern, Control of rats and mice. Clarendon Press, 1954) and methylene blue (Davis, Emlen and Stokes, Jour. Mamm., 29: 207–225, 1948). Of these, all but one, Chlorazol Sky Blue, lower or are suspected of lowering the acceptability to *R. norvegicus* of the bait in which they are included. Because it is often desirable to use several dyes at once it was decided, therefore, to examine the properties of a further range. The immediate stimulus was the need for dyes which would make droppings of common rats easily distinguishable inside a sewer and it is therefore possible that some of those rejected might be useful under more favorable conditions.

All the palatability tests were of the "simultaneous choice" type described elsewhere (Bentley, Hammond and Taylor, Plant Path., 4: 120–123, 1955) and the significance of any observed differences in acceptance was estimated by means of Student's "*t*" test. The animals used were wild *R. norvegicus*. Whole wheat was chosen as the bait-base because it is commonly employed in census work in sewers, and 5 per cent glycerine was added to make the dyes adhere to the bait.

Thirty dyes were screened for ability to color rats' droppings when fed in the glycerine-wheat mixture. Twenty-four of these were found not to stain droppings conspicuously. They were: Acid Orange G (Color Index 27), Acid Red 117199 (CI 31), Acid Yellow CYR, Acid Yellow FWA, Acid Yellow G Kond (CI 16), Acid Violet 48659 (CI 698), Amaranth B (CI 184), Anatto Substitute 33333, Acid Yellow 2G 64556 (CI 639), Egg Yellow AP, Carmoisine GRN (CI 179)), Gooseberry Green 41928, Indigo Carmine 99020 (CI 1180), Orange Cen (CI 26), Oil Orange N Extra, Oil Yellow G Extra, Pea Green 151984, Pure Orange IMS (CI 150), Rhodamine B 73665 (CI 749), Scarlet 70000 (CI 252), Sky Blue 119000 (CI 672), Sugar Blue 67329, Sunset Yellow FCF 843131, Tartrazol Yellow 67676 (CI 640). Fluoroscein was similarly unsuitable.

The six dyes that were found to be satisfactory were then tested for acceptance in the wheat-glycerine mixture using dry wheat as a standard (Table 1). At the concentrations of eosin, Pea Green 88263, and Acid Magenta 56036 (CI 692) that gave a sufficient depth of color, more plain than colored bait was eaten. The differences in palatability may not have been significant but further tests with these dyes were not justified since the other three, Erythrosine 108678 (CI 773), Acid Green EC (no CI number) and Brilliant Blue FCF (CI 671), were of similar hue and were clearly palatable. Table 1 shows that a concentration of 0.5 per cent Erythrosine definitely lowered acceptance. In three tests at 0.05 per cent there was no obvious difference in acceptance between the glycerine-wheat mixture containing Erythrosine and plain bait ($P = 0.9$). Acid Green was accepted at both 0.05 and 0.1 per cent in preference to dry wheat—presumably because of the glycerine. At 0.1 per cent

TABLE 1.—*Comparative acceptance by Rattus norvegicus of plain wheat and various dyes in the wheat-glycerine mixture*

DYE	CONCENTRATION %	TAKE OF PLAIN WHEAT, gm.		TAKE OF DYED WHEAT, gm.		NO. OF RATS EATING MORE OF "PREFERRED" BAIT		SIGNIFICANCE LEVEL, *P*
Eosin	0.5	523.5		107.0		11/12		
	0.25	521.5		280.0		9/11		
Pea Green	0.5	238.5		219.0		4/6		
88263	0.1	250.0		171.5		4/6		
Acid Magenta	0.5	217.2		193.1		2/6		
56036 (CI 692)	0.1	232.0		182.0		3/6		
Erythrosine	0.5	666.0		195.0		11/12		0.01–0.001
108678 (CI 773)								
	0.05	382.5		322.0		7/11		
	0.05	375.5	1031.2	415.0	1054.1	5/11	16/33	0.9
	0.05	273.2		317.1		4/11		
Acid Green	0.5	118.0		196.0		4/6		0.6
EC	0.1	142.5		262.0		5/6		0.05
Brilliant Blue	0.05	338.1		409.5		8/12		0.2–0.3
FCF (CI 671)								

this preference was significant. A better coloration of the feces results from the use of this concentration. Brilliant Blue FCF, in spite of its name, gave droppings of a bright emerald green color. A choice test at 0.05 per cent showed no sign of an adverse effect on acceptance.

It may be inferred from these tests that in addition to Chlorazol Sky Blue FF200, it would be safe to use Erythrosine 108678 at 0.05 per cent, Acid Green EC at 0.5 per cent and Brilliant Blue FCF at 0.05 per cent, all with glycerine as an adhesive, for movement studies where good bait acceptance is desirable.

I should like to thank Miss E. J. Taylor, Mrs. M. Rowe and J. D. Riley who helped with the experimental work and Messrs. Williams (Hounslow) Ltd., who kindly supplied samples of all the dyes except eosin, and whose nomenclature has been used in this note.—YVONNE LARTHE, *Ministry of Agriculture, Fisheries and Food, Tolworth, Surrey, England.* *Received June 8, 1957.*

DERMOID CYSTS A BASIS OF INDIAN LEGENDS

A tumor specimen has led to the disclosure of the factual basis of a curious Indian legend. Strong (Jour. Mamm., 11: 1–10, 1930), writing of his investigations in Labrador, reported "Certain non-mythical theories adhered to by the Davis Inlet Indian. . . . they say that the abnormal dwarf caribou called *mah-tákw-ah-tée-hoos*, which they have occasionally seen and killed, are carried by the male caribou for six years in a skin sack attached to the belly. Then they are dropped fully developed and accompany the herd. Unlike the larger animals, these dwarf caribou are said never to have botfly holes in the skin."

This legend seems to have been widely held by Indians, for Seton (Life histories of northern animals, vol. 1, pp. 182–183, 1909) wrote concerning moose: "Another curious thing in moose life was reported to me by William G. Tweddell of Woonona, Manitoba. He asked me if I had ever heard of the Peeto-mong-sons or 'Little Moose in the Big Moose.' One moose in about 500, he said, has a little medicine Moose in its skin. When this is found it is a cause

for much rejoicing among the Indians. It is carefully preserved as great medicine, and the man who found it is believed to have secured a mascot of eternal good luck in moose hunting.

"Cross examination did not shake his evidence. It was not a foetus—Tweddell was sure of that. It was in the skin, and usually in that of a bull moose. He had seen two; the most recent one was about a foot long; it had hoofs and hair but no bones."

Much earlier, Richardson (Fauna Boreali-Americana, Part I, pp. 250–251, 1829) described a similar abnormality in a woodland caribou. "The same gentleman mentions that the buck has a peculiar bag or cyst in the lower part of the neck about the bigness of a crown-piece, and filled with fine flaxen hair neatly coiled round to the thickness of an inch. There is an opening through the skin near the head leading to the cyst but Mr. Hutchins (Hudson's Bay Company manager at York Factory) does not offer a conjecture as to its uses in the economy of the animal."

Seton (*op. cit.*) correctly deduced that the abnormality was a dermoid cyst, which is rarely but regularly found in domestic animals. It may contain hair, teeth, nails or other products of the ectoderm. However, the Indian legends of "dwarf moose or caribou" might be based upon the occurrence of teratomas—abnormal repressed twins.

One can well imagine the interest in the object which accompanied the following letter in French addressed to the National Museum of Canada by a Montagnais Indian at Shefferville (Knob Lake), Quebec, and referred to this Service.

29 October, 1956.

I am sending for analysis, a "little caribou" growth which was found between the flesh and the hide. After the completion of its development this growth may reach a size of about 30 lbs. When the caribou dies, the little one remains alive (having killed the big one). When the little caribou comes out of the skin it resembles a two-year-old caribou. You may see the hair in the specimen I am sending. In the north it is very rare. I would like to study this more and hope that you will give me some details.

JEROME ST. ONGE,
Indian Reservation,
Shefferville, North Shore,
Province of Quebec.

The specimen consisted of a circular-shaped cyst about 5.8 cm. in diameter and 2.5 cm. thick at the point of attachment. The wall of the cyst was thin and transparent. The cavity contained tightly packed flaxen hair in a whorl about a central axis at the point of attachment. The specimen probably came from an eastern woodland caribou, *Rangifer caribou caribou*.

Thus a rare abnormality seems to be the physical basis for a legend widely held among Canadian Indian tribes.—A. W. F. BANFIELD, *Canadian Wildlife Service, Ottawa, Canada. Received July 1, 1957.*

DIGESTIVE ENZYMES OF MOLE, BAT AND RAT

Digestive enzymes of man, domestic animals and laboratory mammals have been catalogued (Spector, 1956). It would seem desirable to have a broader base for generalization concerning digestive abilities of the Mammalia and to have specific information about additional species. Digestive tracts of representatives of the Insectivora and Chiroptera have been examined qualitatively for enzymes present. Determinations were also made on white rat, for comparison and control.

Materials and methods.—Animals used included the Eastern mole, *Scalopus aquaticus*, the Eastern pipistrel, *Pipistrellus subflavus*, the gray myotis, *Myotis grisescens*, and the white laboratory rat, *Rattus norvegicus*. The moles were trapped by use of choker traps, which were checked every four hours or more frequently. Tissues from 11 moles were tested in separate

TABLE 1.—*Digestive enzymes of mole, bat and rat; + indicates a positive reaction (presence of enzyme), — a negative reaction (enzyme not present)*

ENZYME	SALIVARY GLAND			STOMACH			PANCREAS			SMALL INTESTINE		
	M.*	B.*	R.*	M.	B.	R.	M.	B.	R.	M.	B.	R.
Pepsin	—	—	—	+	+	+	—	—	—	—	—	—
Trypsin	—	—	—	—	—	—	+	+	+	—	—	—
Rennin	—	—	—	+	—	+	—	—	—	—	—	—
Amylase	+	+	+	+	+	+	+	+	+	+	+	+
Maltase	—	—	—	—	—	—	—	—	—	+	+	+
Lactase	—	—	—	—	—	—	—	—	—	—	—	—
Sucrase	—	—	—	—	—	—	—	—	—	+	+	+
Lipase	—	—	—	—	—	—	+	+	+	—	—	—
Cellulase	—	—	—	—	—	—	—	—	—	—	—	—
Chitinase	—	—	—	—	—	—	—	—	—	—	—	—
Alk. phosphatase	—	—	—	—	—	—	—	—	—	+	+	+
Carboxypeptidase	—	—	†	—	—	—	+	+	+	+	+	+
Dipeptidase	†	†	—	†	—	—	+	+	+	+	+	+
Aminopeptidase	+	‡	+	+	‡	+	+	‡	+	+	‡	+

* M = mole; B = bat; R = rat.
† Weak positive or "trace" reaction.
‡ Bat digestive organs were not tested for aminopeptidase.

experimental runs. There were 5 adult males, 4 adult females, 1 juvenile male, and 1 juvenile female. Age determinations were made according to dentition, pelage and size criteria previously found to be effective with Insectivora (Conaway, 1952). Bats were collected from Hunter's Cave, Boone County, Missouri. Tissues of 4 *Myotis* were combined for the tests of bat enzymes, and a separate run was made on the combined pancreatic tissue of 8 *Pipistrellus*. Four adult male rats were tested in separate runs. Bats and rats were starved 24 hours before use. Most of the moles were killed in trapping, but three animals taken alive (the two juveniles and one adult male) were similarly starved prior to use.

Glycerated filtrates from macerated salivar, gland, pancreas, stomach and small intestine were used to test for the presence of the following enzymes: pepsin, trypsin, rennin, amylase, maltase, lactase, sucrase, chitinase, cellulase, lipase, alkaline phosphatase, carboxypeptidase, dipeptidase and aminopeptidase. Unless otherwise stated the qualitative tests used were adapted from those of Hawk *et al.* (1954).

Tests for carboxypeptidase, aminopeptidase, and dipeptidase were made using the methods of Grassman and Heyde (1929), Bergmann and Fruton (1944), Smith and Bergmann (1944) and Colowick and Kaplan (1955). The substrate for carboxypeptidase was chloroacetyl-L-tyrosine, for dipeptidase the substrate was glycylglycine ethyl ester HCl, and the substrate for aminopeptidase was L-leucylglycylglycine. Control blanks were run for each determination in all the enzyme tests, and always were negative.

Results and discussion.—Results are summarized in Table 1. Those reported for bat are for *Myotis grisescens*. Pancreatic extracts of *Pipistrellus subflavus* were used in one experiment and the results obtained were the same as obtained with *M. grisescens*. There were no detectable differences in enzyme complements of moles of different ages and sexes.

In general, distributions of digestive enzymes in the species studied resemble those reported for other mammals (Spector, 1956). Occurrence of salivary amylase is irregular in the Mammalia. Myrback and Neumuller (1950) specify that it has been found in certain apes, man, pig, squirrel, mouse and rat, but is absent or almost absent in domestic cat, dog, goat and horse. The enzyme also has been reported for rabbit (Carlson and Crittenden, 1910).

Positive results for salivary amylase in mole and bat are suggestive, but must be interpreted with caution. Occurrence of some amylytic activity could be expected from almost any vertebrate tissue macerate (Sumner and Somers, 1953) and all mole, bat and rat tissues tested were qualitatively positive for amylase.

The enzyme, lactase, has been found in small intestine of a variety of young mammals, including rat (Heilskov, 1951). Failure to record positive lactase reaction in the experiments reported here is probably due to selection of mature animals for the tests. Two of the moles used were juveniles, but well past weaning. All other animals were adults. Other results of interest include the absence of rennin in stomach of *Myotis grisescens* and the appearance of trace amounts of dipeptidase and carboxypeptidase in salivary and stomach tissues of some of the species studied.

Summary.—Digestive enzymes of the salivary glands, stomach, pancreas and small intestine have been catalogued for the Eastern mole, *Scalopus aquaticus*, gray myotis, *Myotis grisescens*, and laboratory rat, *Rattus norvegicus*.

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R. H. Buchholz, *Dept. of Biology, Monmouth College, Illinois*; P. H. Wells, *Dept. of Biology, Occidental College, Los Angeles*; and C. H. Conaway, *Dept. of Zoology, Univ. of Missouri, Columbia.* *Received June 29, 1957.*

A METHOD FOR CORRELATING BLADDER EMPTYING AND TOTAL ACTIVITY IN RODENTS

An inexpensive appartus has been designed and used for the simultaneous recording of bladder emptying and total activity displayed by rodents. The animal is housed in a galvanized can which is placed between two pieces of mesh serving as the top and bottom of the cage (Plate I). A graduated tube is attached to the cage allowing for the measurement of water consumption. Food pellets may be left inside the cage. Upon urination, the urine

flows through a plastic funnel and over a glass bulb which pinpoints the sample on the sloped rim of a revolving paper plate. The paper plate is rotated once in 24 hours by a clock mechanism. The time of urination may be ascertained by superimposing a transparent clock face over the plate. Each cage is mounted on tambours set up as a tripod. The tambour arrangement consists of thistle tubes covered with dental dam upon which corks are placed to support the cage. The tambours for each cage are connected separately by rubber tubing to a writing pen, and activity is recorded on a 24-hour kymograph. A separate light above each cage is automatically controlled by a poultry-house light switch.

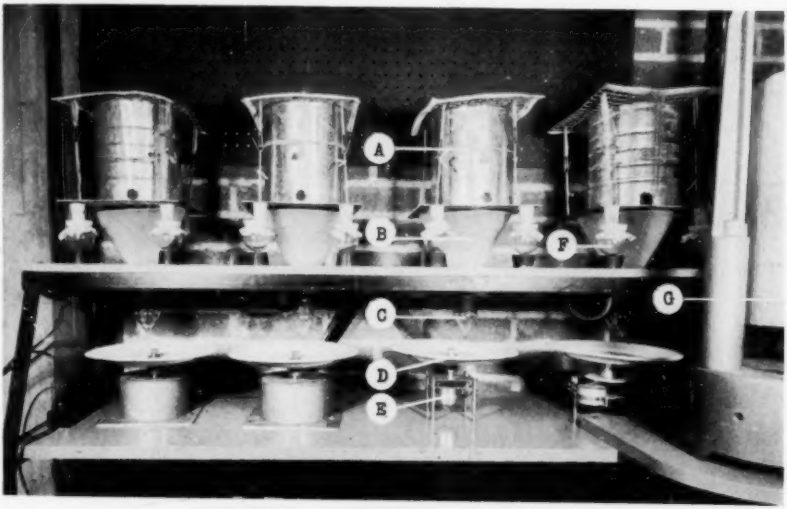

PLATE I

Equipment for recording bladder emptying of rodents. *A*, animal cage; *B*, plastic funnel; *C*, glass bulb; *D*, rotating paper plate; *E*, 24-hour motor; *F*, tambour; *G*, 24-hour kymograph.

TABLE 1.—*Records of bladder emptying of four male hamsters; mean value for 52 days*

ANIMAL NO.	NO. SAMPLES BY NIGHT	NO. SAMPLES BY DAY
1	3.1 (59%)	2.1
2	3.8 (56%)	3.0
3	2.7 (56%)	2.2
4	3.8 (55%)	3.0

This apparatus has been demonstrated to be effective for the recording of bladder emptying. Preliminary results on the golden hamster indicate that about 56 per cent of voiding occurs at night in this species (Table 1). A simple modification of the equipment makes it possible to collect the urine for analyses. A metal disk containing 24 overlapping test tubes can replace the paper plate as described.

This research was aided by a grant from the Sigma Xi–Resa Research Rund.—MONA R. MELTZER AND G. EDGAR FOLK, JR., *Dept. of Physiology, State Univ. of Iowa, Iowa City.* *Received May 14, 1957.*

A METHOD OF ATTACHING SKIN AND SKULL SPECIMENS

The wildlife management program was initiated at The Pennsylvania State University in 1938. We were cramped for space and had little storage room. As time went on we began to build up a teaching collection of bird and mammal skins.. The collection now has over 2,500 bird skins and nearly 800 mammal skins.

In order not to lose skulls belonging to the museum skins, the writer devised a method, still in use, of attaching the skulls to the skins. The method employed was very simple and has proved to be practical as far as our collection is concerned.

The method used was to clean the skull as usual, give it the same number as on the skin label and then roll it in a piece of cellophane, making it like a tube. Next one end was folded and bent back over a strong thread. This was then stapled with an ordinary stapling machine. The other end was folded back and held in position with a paper clip. The skull was then tied to the right hind leg where the label was also placed (Plate I).

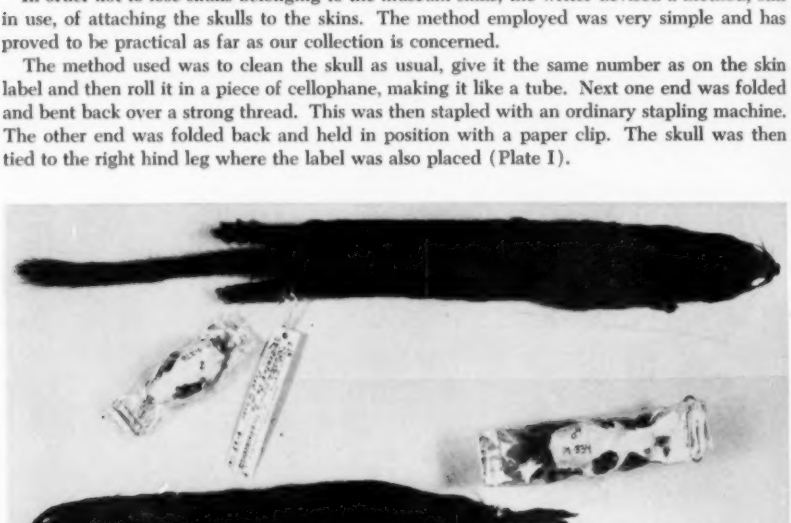

PLATE I

Two museum skins, showing the method of attaching skulls in cellophane.

If it becomes necessary to study the skull, most of the features may be seen through the cellophane with a hand lens. If closer scrutiny is desired, the paper clip can be removed and the skull slipped out of the cellophane. After study or close inspection, the skull may be slipped back into the tube and the paper clip replaced, holding the skull in position for storage.

This system of attaching the skulls to the specimens has saved storage space, has been simple to do and, most of all, has resulted in no loss of skulls. Even where the skins and skulls have been handled by students in the mammalogy classes, they have lasted well over the years.

The cellophane may be purchased in rolls 30 inches in width. We are still using from a roll purchased in 1938.—P. F. English, *The Pennsylvania State Univ., University Park, Penn.* *Received June 27, 1957.*

REVIEWS

Tomilin, A. G. Zveri SSSR i Prilezhashchikh Stran (The Mammals of the USSR and adjacent Countries). Vol. IX. Kitoobraznye (Cetacea). Publ. Acad. Nauk USSR, Moscow. 756 pp., XII pl. (in color), 146 figs., 196 tables, Appendix (7 tables). 1957. [In Russian.]

After the death of S. I. Ognev in 1951, V. G. Heptner was chosen as general editor of the remainder of this important series. The present volume, begun by Tomilin under the direction of Ognev, is the first to come out since Vol. VII appeared in 1950, and is fittingly dedicated to Ognev, the founder of the series and teacher of both Heptner and Tomilin. The first six pages of the text are devoted to "Sergei Ivanovich Ognev and his 'Mammals of the USSR,'" a review and obituary by Heptner. In this section, incidentally, it is explained that Vol. VIII was to include the remaining subfamilies of rodents not covered in earlier volumes: Murinae and Cricetinae, to be prepared by Ognev; Gerbillinae, to be written by Heptner. Ognev was only part way through the genus *Rattus* when he died and the work was not completed. I could find no further mention of the fate of Vol. VIII.

The reader is directed to an earlier review by Quay (Jour. Mamm., 32: 472–474, 1951) for the general plan of the Mammals of the USSR series. The present volume follows the general format of those preceding. It draws on Russian and foreign publications alike and presents, in addition, much original information based on Tomilin's own research and vast experience. Thirty-one species of cetaceans are covered, including eight which are considered as probable members of the USSR fauna.

The material is presented in systematic order, with the usual treatment of general information and characterizations of the suborders, families, subfamilies and genera, and with keys to families, genera and species. For each species there are presented first a synonomy, a list of common Russian and foreign names, and a list of publications which contain illustrations of the species. Then the text is divided into the following headings: Nomenclatorial notes, External appearance and skeleton, Geographic distribution and migrations, Biology, Trade and production, Subspecies (where applicable). The first of these includes a brief taxonomic history of the species, the second is subdivided into sections on size, form and proportions, color, skull, teeth, sternum, vertebrae, fins and appendages. Biology includes: food, reproduction, behavior and nature, maintenance in captivity (where applicable), parasites and diseases, and occasionally other subheadings. Needless to say, the coverage is not the same for all species, varying in relation to the abundance and/or commercial importance of each. For instance, five pages are devoted to *Neomeris* and seven to *Mesoplodon bidens* (and several others), as contrasted with 56 pages for *Delphinus* and 70 for *Balaenoptera physalus*. Such discrepancies are due, of course, to the general lack of knowledge concerning some species and not to any purposeful slighting or omissions.

The drawings in the text are, with few exceptions, clear and well done, adding considerably to the work as a whole. The color plates by N. N. Kondakov and V. A. Vatagina are for the most part well executed, if at times a bit inaccurate. The photographs leave something to be desired, being quite variable in quality and often not very clear.

The taxonomic treatment of the porpoises and dolphins, in particular, follows a policy of "lumping" allopatric species of widely distributed genera. Species which are questionable or poorly known are usually also included in the synonymies. Those occurring in USSR waters are often given subspecific standing. Thus, *Tursiops nuuanu* Andrews and *T. gilli* Dall are listed as synonyms of *T. truncatus* (Montagu), *gilli* being considered a subspecies. On the other hand, *Orcinus rectipinna* (Cope) is listed as a synonym, but not recognized as a subspecies, of *O. orca* (Linnaeus). This treatment represents, perhaps, a healthy approach, although in some cases it is not entirely justified by available evidence. For instance, Tomilin considers the genus *Globicephala* monotypic, listing *G. scammoni* Cope as a subspecies of *G. melaena* Thomas, for which latter he uses *Globicephalus melas* (Traill). For an illustra-

tion of the skull of *G. melaena*, he shows Cope's drawing of *G. brachypterus* Cope (1876, Proc. Acad. Nat. Sci. Phila., p. 129). There is, however, evidence that *G. macrorhyncha* Gray (=*G. brachypterus*) may well be distinct from *G. melaena*, and the affinities of *scammoni* are not yet known (F. C. Fraser, 1950, Atlantide Rept. No. 1, pp. 51–60). Unfortunately, the species *Globicephala leucosagmaphora* Rayner was overlooked, although reference to Rayner's paper (1939, Ann. Mag. Nat. Hist., Ser. 11, IV: 543–4) was apparently made in the documentation of geographic records. This brings up the most frustrating aspect of this work. The text is replete with literature citations, but the only ones for which complete references may be found are those listed for their illustrations (see above—53 of the 67 references in the text of the section on *Globicephala* occur only as author-date citations). Nowhere in the entire book is a bibliography to be found. Needless to say, this detracts considerably from the value of the publication.

However, even considering its few shortcomings, this book is one of the more important recent additions to the literature of marine mammalogy. The wealth of information on variation, natural history and general biology of the Cetacea brought together within its covers makes it an extremely valuable reference. It is unfortunate that the language barrier prevents the contents of this work from being more readily usable.—ANDREW STARRETT.

Young, J. Z. THE LIFE OF MAMMALS. Oxford University Press, New York. Pp. xv + 820, illus. January, 1957. Price, $10.00.

The author, J. Z. Young, has written THE LIFE OF MAMMALS in a way that few other people could or would. From the point of view of the mammalogist, ecologist, and even the general zoologist, this volume is perhaps not a life of mammals at all, but is more nearly mammalian anatomy and physiology.

Mr. Young had many years of experience in the fields of zoology and comparative anatomy before assuming his present post as Professor of Anatomy at University College, London. This background and interest suit him admirably to assume the task he has undertaken in this volume which "presents mammalian anatomy, physiology, histology, and embryology as they are and at the same time tries to show what in the future they may be." The book is not intended for the beginner, but rather is "to be used as a systematic aid to the student of mammals and man who has already some general familiarity with biology. It should serve as a companion to a course of practical study of dissection and of histology and embryology. Drawings of dissections and sections are included with the hope they will be found useful in the laboratory." Special reference is made to the rabbit in both the text and the illustrations.

The first chapter, in a way, represents the author's philosophy of the organism and its control as expressed in the language (often inadequate) of a changing world. This is not easy reading, but the author recommends that it be read before passing on to the rest of the book. The next chapter deals with the structure and function of the skin, including temperature control, expression, body shape, and color in mammals. In addition to the expected coverage in such a chapter, it is spiced with such statements as "the African elephant increases its total surface area by nearly one-sixth when it raises its ears" as a method of temperature control.

Chapters III to IX describe body support and locomotion, including the histology and physiology of the tissues involved. Included also is a chapter which might be termed bio-engineering since it deals with the principles of engineering as applied to muscle-skeleton preparations. This chapter may be a little on the heavy side for some biologists but it is rewarding.

The section on the organ systems is introduced by two chapters: one on the head which discusses cranial contour, bones, nerves and muscles; a second one deals with tooth structure, development and evolution, and a brief survey of the salivary glands.

Chapters XII to XVI present the organ systems in the following order: digestion, internal environment and composition of body fluids, the heart and circulation, respiration, excretion and the control of water balance. Not only the conventional information is given but also new contributions, such as those yielded by the electron microscope.

Teachers of neuroanatomy should be heartened to see a volume that makes an excellent attempt to give a good background on the nervous system (something that the average beginning medical student does not now have). Thirteen of the 47 chapters, or practically one-fourth of the book, are devoted to an up-to-date presentation of the anatomy, physiology and development of the nervous system (including special senses and end organs.)

Chapters XXIX to XXXIII are concerned with the endocrine system, exclusive of the gonads, and include a history of the hormone concept and an outline of the evolution of the system.

The remaining 14 chapters deal with various aspects of development, including the reproductive cycle and placentation. This section covers such problems as rates of cell growth and division, cell differentiation, origin of the ovum, egg types, fertilization, cleavage and gastrulation. One chapter on the sequence of differentiation and another on a comparative survey of gastrulation in vertebrates deal so much with experimental embryology that perhaps one could question their inclusion in this volume. Naturally, lower vertebrates, especially the amphibians and birds, are the chief subjects for discussion, not mammals.

An up-to-date bibliography of 295 references is included. Only 15 of this number antedate 1930, and 180 of them bear dates of 1950 or later.

Here, then, is a well-written volume that should attract the attention of teachers of courses in advanced anatomy, and in anatomy courses slanted specially for pre-medical students. It may well encourage the organization of such courses, on both a graduate and undergraduate level, where they do not now exist.—KENNETH L. DUKE.

Muybridge, Eadweard. ANIMALS IN MOTION. Edited by Lewis S. Brown. Dover Publications, Inc., New York. 440 pp., 183 pl. + 21 figs. and 24 other illus. November 10, 1957. Price, $10.00.

In San Francisco there was revived, in the spring of 1872, an ancient controversy concerning animal locomotion. Leland Stanford, the railroad tycoon, wagered $25,000 that a trotting horse, at some portion of its stride, had all four feet free from the ground. To settle the dispute a brilliant young photographer, Eadweard Muybridge, was commissioned to make a series of high-speed photographs. The results not only settled the argument in favor of Stanford but led to the publication, in 1887, of the 11-volume ANIMAL LOCOMOTION. This work, a landmark in photography and biology, was based on over a hundred thousand photographic plates; it contained more than 20,000 figures in 781 photoengravings. The price of the set was $550.

The present volume, together with its companion, THE HUMAN FIGURE IN MOTION, makes available a definitive selection of Muybridge's work in convenient form. ANIMALS IN MOTION contains 3,919 action shots, taken at speeds up to 1/6000 of a second, in strip sequence; it illustrates 27 different mammals and 7 birds in 123 characteristic actions. The majority of the plates depict domestic animals. The horse alone is shown in 85 plates, portraying the amble, trot, rack (or pace), canter, gallop and walk (one series with a Lady Godiva) as well as showing the animal leaping, rearing, kicking and hauling a load. Other series include the cat, dog, camel, goat, ox and sow; wild animals, photographed at the Philadelphia Zoo, include the raccoon, capybara, baboon, deer, bison, sloth, gazelle and others. Most series picture the consecutive phases of a complete stride; the time-interval between phases is indicated. Actions are illustrated against ruled backgrounds; most are shown in lateral view, some from front or rear as well. Clarified are such questions as leg coordination, head move-

ments, spine patterns, how a lion places his feet, the action of an elephant's knee, the position of a kangaroo's legs in mid-leap.

Most of the plates are remarkably clear, especially in view of the difficulty of reproducing old, often faded, photographs. Critics should recollect the problems facing the photographer, who served also as his own chemist in using the wet collodion plate or the early dry-plate process, in stopping a horse's hoof moving at more than 30 yards per second. The early photographs deficient in lighting or clarity have been largely eliminated from this edition.

Much useful material is contained in the 74 pages of front matter—an account of Muybridge and his work, the original preface, an introduction and a detailed analysis of locomotion in terrestrial quadrupeds, all carefully arranged and provided with helpful diagrams and figures. This volume will remain a basic authority on the movements and gaits of most mammals.—RICHARD H. MANVILLE.

Errington, Paul L. OF MEN AND MARSHES. The Macmillan Co., New York, ix + 150 pp., 22 illus. November 26, 1957. Price, $4.50.

The author is known for his work on muskrats and waterfowl, on predation and populations, and for his aptitude at "reading sign" to interpret the constant drama of the wild. In this book he discusses, in general and popular terms, that subject close to his heart—the biology of the wetlands, be they prairie potholes or oxbow marshes, cedar swamps or peat bogs, desert springs, shallow sloughs, or lakes fringed with reeds and cattails. He gives us glimpses of the Bear River Marsh in Utah and the Malheur Marsh in Oregon, of a Louisiana marsh and the Qu'Appelle River marshes of Saskatchewan. But more particularly he is concerned with those glacial marshes of the plains and prairies of Iowa, Minnesota and the Dakotas which were molded by the Pleistocene ice sheets.

The marsh is considered as a biological entity. On a South Dakota marsh the soras "lift up into flight to drop down again into the next concealing stand of vegetation. . . . One sees wild mallards arising out of the bulrushes in front of a canoe; . . . newly weaned muskrats swim and sit and feed and dress themselves as if they thought they amounted to something. . . . There may be coyotes and jack rabbits, midges and crayfish mounds. . . . A mother mink may be followed by one or two young as she bounds or swims along shore. . . . There may be dowitchers flying in a compact flock or working the mud with long bills; jacksnipes flushing in swift, erratic flight or flying high over the marsh. . . . One view should be of a misty morning with sunlight filtering through, and avocets, willets, and lesser shore birds running along a mud flat. . . . Over all, the medley of blackbird and bobolink calls, of coot and rail and grebe calls, the pumping of bitterns."

Such scenes are described in detail, season by season; reactions to drought and flood, to predation and disease are discussed. The reader gains a deeper appreciation of the complex ecology of these wild areas, and also a bit of the author's philosophy developed in such areas. For marshes are one type of native wilderness that can be profitably enjoyed, and not in a monetary sense, by many people. They have their own values of many sorts. And yet, of the 120 million acres of marshes and swamps our country once possessed, less than a fourth remain fit for wildlife; artificial drainage has accounted for most of the rest. The author makes a strong plea for the preservation of these areas—interestingly enough, at a time when the Nature Conservancy has just acquired the Beckley Bog in Connecticut and the Wauconda Bog in Illinois. It is encouraging that proponents of such conservation are on the increase; this volume will serve, among other things, to bolster their arguments. The drawings by H. Albert Hochbaum add much to this attractive, informative and entertaining book.—RICHARD H. MANVILLE.

Palmer, E. Laurence. FIELDBOOK OF MAMMALS. E. P. Dutton & Co., Inc., New York. 322 pp., illus. November 29, 1957. Price, $3.75.

This latest publication follows the general pattern of the author's previous books in conservation and natural science. In his own words, he hopes that "the junior and amateur naturalist in town or country will find . . . information about the mammals he has the opportunity to see, written in a language that is not too difficult, while technically true. The farmer may be helped to understand his stock, and the vermin with which he has to contend, the housewife her pets and the household pests, the trapper his fur-bearers, and the tourist the strange animals he may see for the first time. . . . It is designed to supplement . . . other books dealing with mammals on a popular and professional basis."

Described are 300 mammals, representing each of the living orders. Great emphasis is put on domestic forms, e.g., 51 varieties of dogs, 12 of cattle and 8 of sheep are considered. Others, for the most part, are common native species, those likely to be seen in zoos, or such curious creatures as the platypus, panda, pangolin, potto and porpoise. Each form is treated on one page with illustrations and notes on physical characteristics, reproduction, ecology, foods, distribution and ways of life. Here and there are larded in accounts—of cattle in myths and religion, the ancestry of horses, management of swine, the ruminants, and dogs in war—which nicely round out the general information in the introductory material.

Each form is figured in the flesh and additional sketches of skulls, dentition, tracks and scats are included for many. The illustrations are generally helpful but many of the supplementary figures suffer from crowding and overreduction; a number are so sketchy as to be unrecognizable, such as the skull of the red squirrel, scat of the bobcat and trail of the deer. The pigmy hippo pictured resembles a grotesque lamb. The end papers provide charts and silhouettes representing the phylogeny of mammalian orders, the role of mammals as predators, and the affinities of 66 breeds of dogs.

An oversight left the elephants in the order Proboscidae, as well as the pigmy hippo in the genus *Hippopotamus* and both Malay and Amazon tapirs in *Tapirella*. But this does not aim to be a technical treatise, and it does contain a wealth of general and specific data that should appeal to students and teachers of nature study and to all others with an interest in "our hairy and furry fellow inhabitants of the earth."—RICHARD H. MANVILLE.

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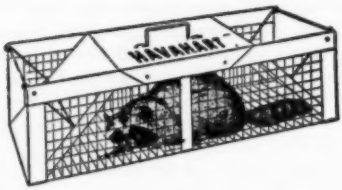

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A recently published bulletin on the construction of a low-cost laboratory mouse cage drinking fountain, that is also very easy to build, is available free of charge from the Thorne Ecological Research Station, 1707 Hillside Road, Boulder, Colorado. Ask for Bulletin No. 5.

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PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Bills will be rendered following publication.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

FOR SALE—*Live desert rodents.* Send for information and price list. Keith E. Justice, 44 W. Rillito St., Tucson, Arizona.

WANTED—*Preserved specimens,* just hatched or born, full term; all species; identified; maximum 12 hours. David Wetherbee, Hampton, Connecticut.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

CORRECTIONS

Dr. Harrison's recent move to The Queensland Institute of Medical Research, Brisbane, Australia, together with the editor's shift to a new base, led to a few oversights in the article on "Range of Movement of Some Malayan Rats" in the May issue of the Jour. Mamm., 39 (2). Corrections should be made as follows: p. 191, line 1, for *Miller's* read *Müller's*; p. 194, line 8, for 7 (*66*) read 7 (*6.6*); p. 197, legend to Fig. 6, for *117 meters* read *117 meters standard deviation*; p. 206, after citation to Harrison, 1957, for *in press* read *1–21.*

COMMENTS AND NEWS

RESEARCH GRANTS

The Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the life sciences is Sept. 15, 1958. Proposals received prior to that date will be reviewed at the Fall meetings of the Foundation's Advisory Panels and disposition will be made approximately four months following the closing date. Proposals received after the Sept. 15, 1958, closing date will be reviewed following the Winter closing date of January 15, 1959. Inquiries should be addressed to National Science Foundation, Washington 25, D. C.

SOVIET RESEARCH RESULTS

Pergamon Institute, a non-profit foundation for the furtherance and dissemination of scientific knowledge, has recently been formed in Washington, D. C., and is in course of formation in London, for the purpose of making available to scientists of U.N. member nations the results of scientific, technological and medical research and development in the U.S.S.R. and other Soviet orbit countries. Russian sources indicate that some 24,000 scientists, or about 14 per cent of Soviet scientific manpower, are engaged in basic research. Journals, books and individual papers in these fields are largely unavailable to 98 per cent of American scientists because of the language barrier.

Pergamon Institute is now publishing, in English translation, 16 Russian journals; 22 books are being translated. A series of review volumes covering the period 1920–1956, with complete bibliographies, is being considered. Any learned society or individual scientist may request a free monthly contents list of significant articles and books currently being published in his field of interest. Full English translations of any article listed will be supplied with a minimum of delay on a cooperative cost-sharing basis, i.e., costs will be shared equally by all requesting the article over a period of six months. The Institute will also undertake to supply, on request, detailed and exhaustive bibliographical information on work published in Russian on any subject in these fields; such services will be charged at cost. Arrangements may be made for abstracts and résumés of any work, for the additional translation of selected journals and books if suitably recommended, and indeed for translation work in these fields from and into any language, including Chinese and Japanese.

The Translation Panel of the Institute is urgently in need of qualified translators from Russian and other Slavonic languages who are able and willing to undertake translation work on a spare-time basis for which they will be remunerated. Communications should be addressed to the Administrative Secretary of the Institute at 122 East 55th Street, New York 22, New York.

SECRETARYSHIP OF INTERNATIONAL COMMISSION

Francis Hemming, Honorary Secretary to the International Commission on Zoological Nomenclature since 1936, has been forced by ill health to retire from this office. He will, however, see through the press the OFFICIAL LISTS and OFFICIAL INDEXES now in preparation and will prepare the OPINIONS on a number of cases already decided by the Commission.

R. V. Melville, a senior member of the paleontological staff of the Geological Survey, was released on May 1, for a period of one year, to accept appointment as "Assistant Secretary to, and Director of the Office of, the International Commission on Zoological Nomenclature," to complete the arrangements for the meeting of the Colloquium on Zoological Nomenclature held in London last July, and to serve as Recorder for the Section on Nomenclature of the International Congress of Zoology.

MISSION 66

Those who have recently visited any of the 181 areas administered by the National Park Service are aware of a new project under way. MISSION 66, a ten-year program to culminate with the celebration of the Golden Anniversary of the Service, has recently completed its first year—a year which saw the addition of a twenty-ninth National Park and a new National Monument. MISSION 66 aims to expand and improve the System and its services in anticipation of at least 80 million annual visitors by 1966. Our best wishes go to the National Park Service in its vital role of managing our heritage of wilderness, scenic, scientific and historic resources, making them accessible for recreational purposes while interpreting and safeguarding them for the enjoyment and inspiration of future generations.

LEEDY HONORED

The American Motors Corporation, of Detroit, annually honors ten professional and ten non-professional conservationists with bronze plaques and cash awards. At the recent meeting of the Society at Tucson, Arizona, on June 17, Dr. Daniel L. Leedy, Chief of the Branch of Wildlife Research of the U.S. Fish and Wildlife Service, was so honored for his work as supervisor of the nationwide cooperative wildlife research program operating in 17 land-grant colleges. The presentation was made by Dr. Keith R. Kelson.

GRATIS REPRINTS

Beginning with the issue of February, 1959, the Society, by recent action of the Directors at the annual meeting in Tucson, is discontinuing the practice of providing authors of major articles with free reprints.

CHANGE OF ADDRESS

Several weeks are required for changes of address on the Society's records to become effective. Mailing addresses for the Journal will not be changed unless notification is received by the Secretary-Treasurer prior to the 1st of the months of issue (February, May, August and November).

WORLD CONGRESS

Announcement has been received that the Third World Congress on Fertility and Sterility will be held in Amsterdam, Holland, from June 7 to 13, 1959. Emphasis will be placed on the topics of embryonic death, hormonal factors and vitamins, endocrine functions, biochemistry of spermatogenesis and psycho-sexual problems. Further information may be obtained from Dr. L. I. Swaab, Honorary Secretary of the Congress, Sint Agnietenstraat 4, Amsterdam-C, Netherlands.

HONORARIA

Two honoraria are available each year for young mammalogists who have not obtained the Ph.D. degree. These honoraria carry a stipend of $100.00 each to help defray the expenses of travel to the annual meetings for the presentation of the paper. In 1959 the meetings will be held in Washington, D.C., about the middle of June. Entries should be submitted to Dr. Stephen D. Durrant, Department of Zoology, University of Utah, Salt Lake City, Utah, before April 1, 1959.

RESOLUTIONS

Members having resolutions intended for action by the Society at its next annual meeting are urged to submit them to the Resolutions Committee at the earliest opportunity. The committee is anxious to submit the proposals to the members prior to the meeting but can do so only if they receive such proposals at an early date. May 1, 1959, has been set as a deadline. Proposed resolutions should be sent to the Committee Chairman, Dr. Keith R. Kelson, National Science Foundation, Washington 25, D.C.

TAXONOMIC PAPERS

The backlog of manuscripts for the Journal is such that publication is currently delayed by over a year. In consideration of priority, however, it has been and will continue to be the practice to give preference to short taxonomic papers, printing them somewhat in advance of their regular order.

RUSSIAN TRANSLATIONS

The Canadian Wildlife Service is issuing a series of translations of Russian works on wildlife. The first two volumes pertained to beaver and muskrats; volume 3, now off the press, is entitled "Translations of Russian Game Reports: Arctic and Red Foxes, 1951–55." It is available from the Queen's Printer, Ottawa, Ontario, Canada, at $1.00 per copy.

DEATH OF VINOGRADOV

Word has been received of the death of Dr. Boris S. Vinogradov on July 10, 1958, following an illness of about six months. Known for his many published contributions to mammalogy, he was for many years in charge of the Division of Vertebrates, Zoological Institute, Academy of Sciences, Leningrad, U.S.S.R.

DEATH REPORTED

A. H. Booth, March, 1958

SUGGESTIONS TO AUTHORS

The *Journal of Mammalogy* publishes original papers with significant new material on any phase of the science of mammalogy. While authors need not necessarily be members of the society, it is suggested that those doing serious work in this field consider carefully the desirability of affiliating with the American Society of Mammalogists.

Papers are generally published in order of receipt with some exceptions at the discretion of the editor. Papers over 20 printed pages in length are rarely published because of cost and space limitations. When subsidized, however, such papers may occasionally be published. Photographic and tabular matter, likewise, will be accepted only when necessary to the exposition of the paper and when the data or point presented are not repeated in the text.

A neat, carefully prepared manuscript is assured more favorable consideration by the editors. It also expedites processing and is more likely to appear in print as the author intended it. Toward this end, the following suggestions are offered as a guide:

All manuscripts should be typewritten on one side only of a good quality white bond paper, preferably 8½ × 11″ in size. All material—*including titles, by-lines, headings, tables, extracts, references and legends*—should be double-spaced. Carbon copies will not be accepted, nor will originals on onionskin or highly glazed paper. Pages should be numbered consecutively in the upper right corner. Tables (with captions) and legends for figures and plates should be typed on separate pages following the text. All margins should be at least 1½″ wide. Do not mark for typography, except to indicate *italics* by underscoring.

Titles should be brief as an aid to bibliography. Usually less than ten words will suffice. Avoid citing scientific names in the title but incorporate them early in the text.

Acknowledgments and reference to sponsorship and contract number are included in the text. Avoid footnotes hung from the text. Note author's affiliation at the end of the article. This should be concise—it is intended to furnish his current address, not his biography.

References, when less than six in number, should be inserted in parentheses at appropriate spots in the text; they should include author, publication, volume, pagination and year, but not title unless a book. More extensive references, arranged alphabetically by author and with title included, are grouped under "Literature Cited." In general, our bibliographic style follows the suggestions made in the A.I.B.S. Bul., 2 (2): 21–23, 1952.

Standard abbreviations are used freely, particularly in tables and with units of measure, *e.g.*, 5.7 mm., 12 cc., 23 lb., 5 hr., 35 mph, 20°C.

Tables should be typed on separate terminal pages and should be arranged as simply as possible to fit Journal page size. It is not always necessary to present all data at hand; the author should exercise some judgment as to what data are essential. Include the units of measure employed. Do not insert rules except in box heads, and then only lightly in pencil.

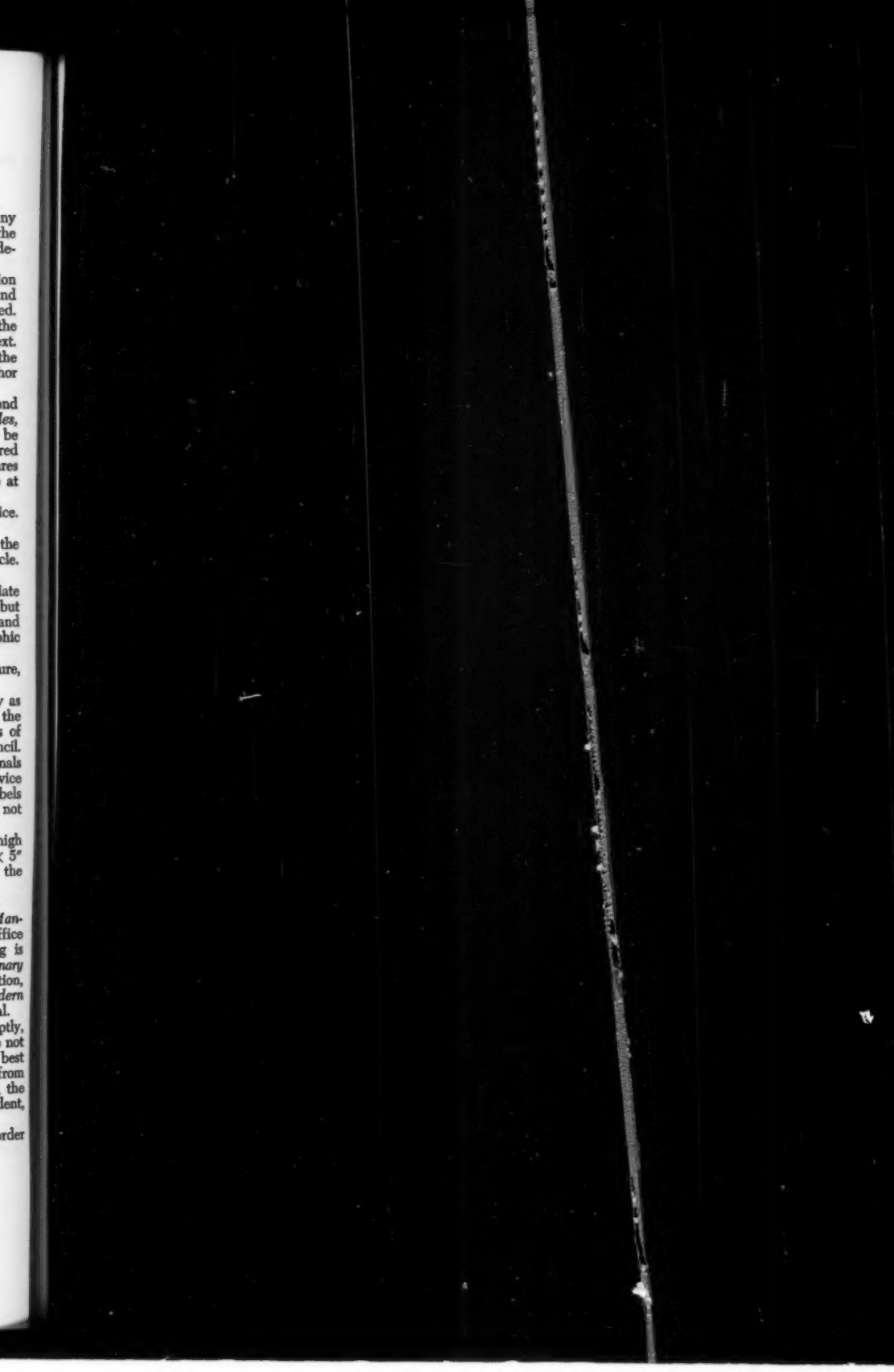
Figures include black-and-white drawings and graphs reproduced as line cuts. Originals should be submitted. Some reduction is desirable, but a drawing need not be more than twice the size of the intended cut. If a scale is included, anticipate its reduction in size. Labels also must be planned to be easily legible when reduced. All lines must be solid black, not gray. Graphs may be made on paper with pale blue lines which will not reproduce.

Plates are photographs reproduced as halftones. The originals must be sharp, with high contrast, and printed on glossy paper; they should be submitted unmounted. A size of 4 × 5″ is ordinarily most convenient. Each should be identified by a light pencil notation on the back. Cropping to remove nonessential portions is often desirable.

A summary, brief and informative, is advisable at the end of major papers.

Authors are urged to consult recent issues of the Journal for examples of styling. *A Manual of Style,* Univ. of Chicago Press, is a standard guide. The Government Printing Office *Style Manual* is especially helpful on capitalization. The final authority for spelling is Webster's *New International Dictionary,* unabridged. Webster's *New Collegiate Dictionary* is adequate for most purposes; it contains a useful appendix with rules for punctuation, capitalization, hyphenation, preparation of copy, and proofreaders' marks. Fowler's *Modern English Usage* is a sound and entertaining reference on grammar and writing in general.

Proof should be read word for word immediately upon receipt and returned promptly, with manuscript, *to the editor.* Errors should be corrected in the margin, but galleys are not the place for widespread corrections by the author. Essential changes or additions are best added at the end of a paragraph, or inserted as a new paragraph. Extensive changes from the original copy will be charged to the author. Cuts should be identified by number, the desired placement of tables and figures indicated in the margin and, where it is not evident, each cut should be labeled TOP on one side.

Reprints may be ordered directly *from the printer* when galleys are checked. An order form is supplied with the proof.

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